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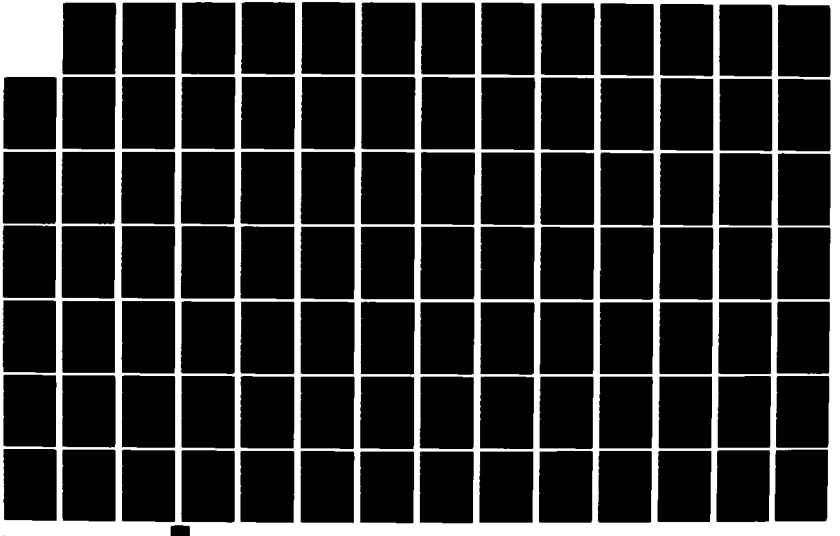

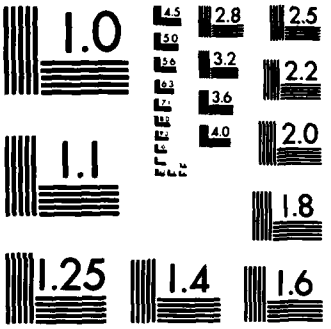

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THE REDUCTION AND ANALYSIS OF RAW DATA TAPES FROM THE AFGL PROJECT OPAQUE DATA PROCESSOR

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Final Report
22 June 1978 - 30 September 1980
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This report describes the additional data processing programs that have been developed to edit, process, and analyze the digital data tapes generated at the U.S. Air Force Project OPAQUE Field Station in Meppen, Federal Republic of Germany. As a continuation of a previous task that was reported in AFGL-TR-78-0176, the efforts described herein detail the processes and procedures developed to maintain, reduce and analyze the large data base representing continuous measurements of atmospheric optical properties in the visible and infrared regions over the past four years.

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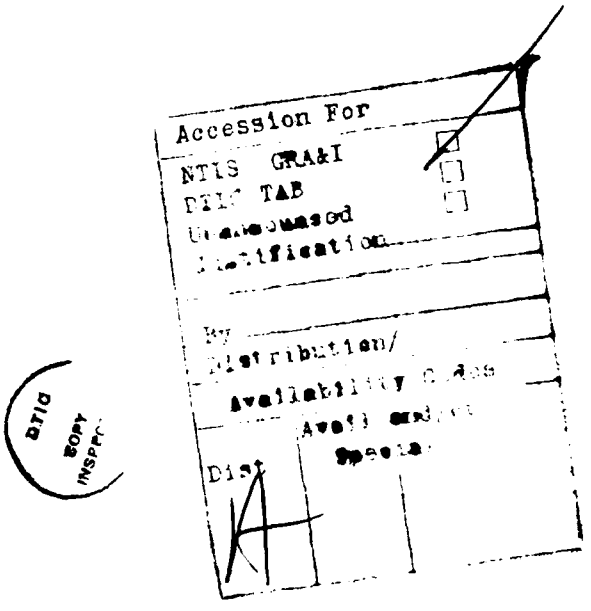

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INTRODUCTION

The objective of Project OPAQUE[1,2] is to gather continuous data from a series of measurements in the visible and infrared regions over a period of several years. This requirement for the continuous data recording of the various experiments has resulted in a large data base that must be catalogued, accessed, edited, reduced, and reformatted for analysis and study. Concurrent with the management of the data base is the requirement of maintaining the central data logger system and its control programs at the West Germany field site.

This report describes all of the additional control programs and procedures that have been developed during this contract period to generate, edit, process, and analyze the digital data tapes and is divided into two parts. Part I of this report describes the data collection phase, the cataloging and access to the data base, and the sensor performance and analysis. Part II describes the additional programs developed for the data searching and stripping procedures, generation of the OPAQUE data bank files, along with the plotting, selection, and display procedures for subsequent experimental analysis.

The program design objectives developed during previous efforts[3] on this task have been retained and refined in the development of the additional programs described herein. Extensive use is made of procedure files to link the necessary programs to perform specific tasks, and thereby simplify their use as analysis tools.

1. Fenn, R.W. (1978) OPAQUE-A Measurement Program on Optical Atmospheric Quantities in Europe, Volume I, the NATO Program, AFGL-TR-78-0011, AD B029877L.

2. Fenn, R.W. (1979) OPAQUE-A Measurement Program on Optical Atmospheric Quantities in Europe, Volume II, the US/German OPAQUE Station Near Meppen, Federal Republic of Germany, AFGL-TR-79-0068, Special Reports, No. 222.

3. Powers, J.E., and Dirkman, R.J. (1978) The Development and Support of the NATO Project OPAQUE USAF System Control Programs, Final Report, Contract No. F19628-76-C-0232, AFGL-TR-78-0176.

I.1 EXPERIMENT SAMPLING SEQUENCES

Due to the changing experimental requirements, the data channel assignments and sampling rates have undergone a number of revisions over the past three years. Table 1. The Data Channel Assignments, given below reflects the changes in the experimental data values sampled and recorded, along with the various sampling rates programmed for each data channel. It should be noted that the data channel numbers are in octal (base 8) which accounts for the fact that channels 8,9,18,19,28,29,38, and 39 do not appear in the table. Each data channel has two discrete digits assigned to it which are used to record filter positions, gain steps, etc. The unused discrete data digits on several of the data channels as used to record the digital output of the sun sensor, the digital rain gauge, and the ceiling meter. The mnemonics listed in the table are derived in most cases from the instrument names and are used to identify the data in the HISTOGRAM and DATA PROFILE plots.

Each data channel is formatted and recorded as a 36-bit string, grouped as 9 hexadecimal digits. The interpretation of these 36-bit strings is as follows:

BITS	INTERPRETATION
0-3	Always the coding for the data sync character, 1101.
4-7	High-order analog channel address, octal.
8-11	Low-order analog channel address, octal.
12-15	Tens digit of discrete data channel, decimal.
16-19	Units digit of discrete data channel, decimal.
20-23	1000's digit of digitized channel voltage, decimal.
24-27	100's digit of digitized channel voltage, decimal.
28-31	10's digit of digitized channel voltage, decimal.
32-35	1's digit of digitized channel voltage, decimal.

Table 1. Data Channel Assignment for Jan., 1978 to Oct., 1980.

Channel	Mnemonic	Sensor Output Sampled	Sampling Rate
0	AGE	AEG, trailer-side unit See NOTE 1	1 min-continuous.
1		Open (formerly MRI1)	1 min-continuous.
1	SNTL	Changed June, 1979 to Laser Scintillometer	1 min-continuous.
2		Open (formerly MRI2)	1 min-continuous.
3		Open (formerly MRI3)	1 min-continuous.
3	SNTL	Changed January, 1979 to Laser Scintillometer	1 min-continuous.
3		Changed June, 1979 to Open	1 min-continuous.
3	AEG2	Changed October, 1980 to AEG,2 meter tower height	20 sec-continuous.
4	LTRO	Eltro, Horizontal path	1 min-continuous.
5	NPH1	NPFM, Filter	1 min-continuous.
6	NPH2	NPFM, Photopic	1 min-continuous.
7	NPH3	NPFM, Range	1 min-continuous.
10		Not Used	
11	VLB1	VPFM, Photopic	1 sec/10 min/hour.
12	VLB2	VPFM, Range	1 sec/10 min/hour.
13	VLB3	VPFM, Filter	1 sec/10 min/hour.
11	AEG8	Changed October, 1980 to AEG,8meter tower height	20 sec-continuous.
12	AE16	Changed October, 1980 to AEG, 16 meter tower height	20 sec-continuous.
13	AE48	Changed October, 1980 to AEG, 48 meter tower height	20 sec-continuous.
14	LSR1	CO2 Laser, PAR Output	1 min-continuous.

15	LSR2	CO2 Laser, Power Output	1 min-continuous.
16	LSR3	CO2 Laser, Angle Output See NOTE 2	1 min-continuous.
17	LSR4	CO2 Laser, Gain Output See NOTE 2	1 min-continuous.
20	TURB	Turbulence on 500 M Barnes	1 min-continuous.
21	BRN1	Barnes 500M Transmissometer	1 min-continuous.
22	BRN2	Barnes 1500M Transmissometer	1 min-continuous.
23	RAIN	Analog Rain Gauge	1 min-continuous.
24	ILM1	Luxmeter, Horizontal Channel	4 sec-continuous.
25	ILM2	Luxmeter, Vertical Channel	4 sec-continuous.
26	ILM3	Luxmeter, Azimuth	4 sec-continuous.
24	ILM1	Changed April, 1980 to Luxmeter, Horizontal Channel	1 min-continuous.
25	AE80	Changed October, 1980 to AEG, 80 meter tower height	20 sec-continuous.
26	LTR1	Changed October, 1980 to Eltro, Slant path	1 min-continuous.
27	DROP	Not used on the data logger but used in the DATA PROFILE and HISTOGRAM PROFILE plots to report the digital rain gauge effective February, 1979.	
30		Not used	
30	A-D	Changed August, 1978 to A/D Reference Channel	1 min-continuous.
31	NEP1	Scanning Nephelometer, Angle	1 sec/30 min/odd hr.
32	NEP2	Scanning Nephelometer, Scale	1 sec/30 min/odd hr.

33	NEP3	Scanning Nephelometer, Photo	1 sec/30 min/odd hr.
34	NEP4	Scanning Nephelometer, Monitor	1 sec/30 min/odd hr.
35		Not used	
36	EPL1	Eppley Pyroheliometer, Filter	1 min-continuous.
37	EPL2	Eppley Pyroheliometer, Direct See NOTE 3	1 min-continuous.
36	ELP2	Changed April, 1980 to Eppley Pyroheliometer, Direct	1 min-continuous.
37	SNTM	Changed April, 1980 to Scintillometer, d.c. monitor See NOTE 3	1 min-continuous.

NOTES:

1. Digital ceilometer is recorded on the discrete digits of channel 0 as: Discrete "tens" = hundreds of ceiling meters.
   Discrete "units" = tens of ceiling meters.
   Installed October, 1980. Operational since March, 1981.

2. Digital rain gauge is recorded on the discrete digits of channels 16 and 17 as: Discrete "units" of channel 17 = 100's rain count.
   Discrete "tens" of channel 16 - 10's rain count.
   Discrete "units" of channel 16 - units rain count.
   These "counts" are multiplied by 25.0 millivolts to allow their display in the PROFILE and HISTOGRAM PLOTS as a voltage. The count range is 0 to 999.
   Operational since December, 1978.

3. Digital sun sensor is recorded on the "tens" digit of channel 37 as: If discrete "tens" digit = 2 or 3, the sun is shining.
   If discrete "tens" digit = 0 or 1, no sun (cloudy or dark).
   Operational since June, 1979.

I.2 OPAQUE RAW DATA TAPE LIBRARY

When a raw data tape is received by the ULowell research team, it is catalogued both manually in the tape log and entered into the system file, TAPEFILE, giving the starting and ending day-of-year, hour, and minute for each continuous data recording. Currently there are over 345 raw data tapes catalogued, a data base representing over four years of essentially continuous OPAQUE measurements. The need for maintaining this raw tape data base has been demonstrated many times where the raw tape must be rerun to create new working files to replace those lost due to a tape mounting problem or a program termination error.

To assist in locating the raw data tape(s) for a given period of time, or to determine if any data was recorded for the period of interest, the programs MEPPEN6, MEPPEN7, MEPPEN8, MEPPEN9, and MEPPEN0 have been designed to produce the Raw Data Tape Directories given in Tables 2, 3, 4, 5, and 6. They are formatted on a calendar year basis with the month-of-year along the abscissa and the day-of-month along the ordinate. The day-of-month is divided into two twelve hour periods as A.M. (00:00 to 11:59 hours) and P.M. (12:00 to 23.59 hours). The values in the columns headed AM and PM are the labels of the data tapes that contain the data for those half-day periods. The value 0 represents either the case that no data was recorded for that twelve hour period or that the month does not contain 31 days.

A careful review of these figures reveals that a given tape may contain a large number of data half-days, while others are in use only for two or three days. This discrepancy is due to the fact that the data logger samples the data channels with different sampling rates. If a large number of one second or four second data channels are sampled and recorded, the data tape lasts for two or three days. If the station operator disables some of these high sample rate channels, the data tape can last beyond 20 days, depending on the data channels disabled. Prior to 1980, the disabling of the sampling of the Scanning Nephelometer (4 data channels sampled every second for thirty

minutes on alternate changing of the Luxmeter sampling from every 4 seconds, continuously to a sampling rate of once a minute, continuous, is evident in April, 1980 and later. The long tape life through the latter portion of 1980 is due to the sampling of the Scanning Nephelometer being disabled by the station operator when the instrument was inoperative.

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	19	22	22	26	26	30	30
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	19	22	22	26	26	30	30
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	19	19	22	22	26	26	30	30
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	14	19	19	22	23	26	26	30	30
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15	19	19	23	24	26	26	30	30
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	19	19	24	24	26	26	30	30
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	19	19	24	24	26	26	30	30
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	19	19	24	24	27	27	30	30
9	0	0	0	0	0	0	0	0	0	0	0	0	9	9	16	16	19	19	24	24	27	27	30	30
10	0	0	0	0	0	0	0	0	0	0	0	0	9	9	16	16	19	20	24	24	27	27	31	31
11	0	0	0	0	0	0	0	0	0	0	0	0	9	9	16	16	20	20	24	24	27	27	31	31
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	20	20	24	24	27	27	31	31
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	20	20	24	24	27	27	31	31
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	20	20	24	24	27	27	31	31
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	20	20	24	0	27	27	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	20	20	0	0	27	0	0	32
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	21	21	0	0	0	0	32	32
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	21	21	0	0	0	0	32	32
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	21	21	0	0	0	0	32	32
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	18	21	21	0	0	0	0	32	32
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	18	21	21	0	0	0	0	32	32
22	0	0	0	0	0	0	0	0	0	0	0	0	10	10	18	18	21	21	0	0	0	0	32	32
23	0	0	0	0	0	0	0	0	0	0	0	0	10	10	18	18	21	21	0	0	0	29	32	32
24	0	0	0	0	0	0	0	0	0	0	0	0	10	10	18	18	21	21	0	0	29	29	32	32
25	0	0	0	0	0	0	0	0	0	0	0	0	10	10	18	18	21	21	0	0	29	29	32	32
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	18	21	21	0	26	29	29	32	32
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	21	21	26	26	29	29	33	33
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	26	26	29	29	33	33
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	22	26	26	30	30	33	33
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	22	26	26	30	30	33	33
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	26	26	0	0	33	

Table 2. OPA/Meppen Raw Data Tape Directory for 1976

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1	33	33	38	38	46	46	53	53	64	64	74	74	84	84	90	90	97	98	104	104	112	112	121	121
2	33	33	38	38	46	46	53	0	65	65	74	74	84	84	90	91	98	98	0	0	112	112	122	122
3	33	33	38	38	0	0	0	0	65	65	75	75	84	84	91	91	98	98	0	0	112	112	122	122
4	33	33	39	39	0	0	54	54	65	65	75	75	85	85	91	91	98	98	0	0	113	113	122	122
5	33	33	39	39	0	0	54	54	0	66	75	75	85	85	91	91	99	99	0	0	113	113	123	123
6	33	33	39	39	0	0	54	55	67	67	75	76	85	85	91	91	99	99	0	0	113	113	123	123
7	0	0	39	40	0	0	56	56	67	67	76	76	85	86	91	91	99	99	105	105	113	114	123	123
8	0	0	40	40	47	47	56	56	67	67	76	76	86	86	92	92	99	99	105	105	114	114	123	123
9	0	0	40	40	47	47	56	56	68	68	76	76	86	86	92	92	99	0	105	105	114	115	124	124
10	0	0	40	40	47	47	56	56	68	68	77	77	86	0	92	92	0	0	105	106	115	115	124	124
11	0	0	41	41	48	48	56	0	68	68	0	0	0	0	92	92	0	0	106	106	116	116	124	124
12	0	0	41	41	48	48	57	57	68	69	0	0	0	0	92	0	0	100	106	106	116	116	124	125
13	0	0	41	41	48	48	57	57	69	69	78	78	0	87	0	0	100	100	106	106	116	116	125	125
14	0	0	41	41	48	48	57	58	69	69	78	78	87	87	0	0	100	100	107	107	117	117	125	125
15	0	0	42	42	48	0	59	59	69	69	79	79	87	0	93	93	100	101	107	107	117	117	125	125
16	0	0	42	42	49	49	59	59	69	70	80	80	0	88	93	93	101	101	107	107	117	117	126	126
17	0	0	42	42	49	49	59	59	70	70	80	80	88	88	93	93	101	101	108	108	117	117	126	126
18	0	0	0	0	50	50	59	60	70	70	80	80	88	88	93	93	101	101	108	108	118	118	126	126
19	0	0	0	0	50	50	60	60	70	70	80	80	88	88	94	94	101	101	108	108	118	118	126	127
20	0	0	0	0	50	50	60	60	71	71	81	81	88	88	94	94	101	101	108	109	118	118	127	127
21	0	35	44	44	50	0	60	60	71	71	81	81	89	85	0	95	101	101	109	109	119	119	127	127
22	35	35	44	44	51	51	61	61	71	71	81	81	89	89	95	95	101	101	109	109	119	119	127	127
23	35	35	44	44	51	51	61	61	72	72	81	81	89	89	95	95	102	102	109	109	119	119	128	128
24	35	35	44	44	51	51	61	61	72	72	82	82	89	89	95	95	102	102	109	110	119	119	128	0
25	35	36	45	45	52	52	61	62	72	72	82	82	89	89	96	96	102	102	110	110	120	120	0	0
26	36	36	45	45	52	52	62	62	72	72	82	82	89	89	96	96	102	102	110	110	120	120	0	0
27	36	36	45	45	52	52	0	63	73	73	83	83	90	90	96	96	103	103	110	110	120	120	129	129
28	36	37	46	46	52	52	63	63	73	73	83	83	90	90	96	96	103	103	111	111	120	121	129	129
29	37	37	0	0	53	53	64	64	73	73	83	83	90	90	96	97	104	104	111	111	121	121	129	129
30	37	37	0	0	53	53	64	64	73	73	83	83	90	90	97	97	104	104	111	111	121	121	130	130
31	37	38	0	0	53	53	0	0	74	74	0	0	90	90	97	97	0	0	111	111	0	0	130	130

Table 3. OPA/Meppen Raw Data Tape Directory for 1977

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1	130	130	137	137	144	144	151	151	160	160	171	171	183	183	0	0	198	198	203	203	208	208	215	215
2	131	131	137	137	144	144	151	151	161	161	172	172	183	183	0	0	198	198	203	203	208	208	215	215
3	131	131	138	138	144	144	151	152	161	161	0	0	183	184	0	192	198	198	203	203	209	209	215	215
4	131	131	138	138	145	145	152	152	161	161	0	0	184	184	192	192	198	198	203	204	209	209	215	216
5	131	131	138	138	145	145	152	152	162	162	173	173	184	184	192	192	199	199	204	204	209	209	216	216
6	132	132	139	139	145	145	152	152	162	162	173	173	184	184	0	0	199	199	204	204	209	209	216	216
7	132	132	139	139	145	145	153	153	162	162	0	174	185	185	0	193	199	199	204	204	209	209	216	217
8	132	132	139	139	145	145	153	153	162	163	174	174	185	185	193	193	199	199	204	204	209	210	217	217
9	132	0	139	139	146	146	153	153	163	163	175	175	185	185	193	193	199	199	204	204	210	210	217	217
10	0	0	140	140	146	146	154	154	163	163	175	175	185	186	193	193	199	199	0	205	210	210	217	217
11	0	0	140	140	146	146	154	154	163	163	175	175	186	186	194	194	199	200	205	205	210	210	217	218
12	0	133	140	140	146	146	155	155	164	164	175	176	186	186	194	194	200	200	205	205	210	210	218	0
13	133	133	140	141	146	146	155	156	164	164	176	177	186	186	194	194	200	200	205	205	210	210	0	0
14	133	133	141	141	147	147	156	156	164	164	178	178	187	187	194	194	200	200	205	205	211	211	0	0
15	133	133	141	141	147	147	156	156	164	164	178	178	187	187	194	195	200	200	205	205	211	211	219	219
16	0	0	141	141	147	147	156	156	164	165	179	179	187	187	195	195	200	200	205	206	211	211	219	219
17	0	0	142	142	148	148	157	157	165	165	179	179	187	187	195	195	201	201	206	206	211	212	219	219
18	0	0	142	142	148	148	157	157	165	165	179	179	188	188	196	196	201	201	206	206	212	212	219	220
19	0	134	142	142	148	148	157	157	166	166	180	180	188	188	196	196	201	201	206	206	212	212	220	220
20	134	134	142	142	148	148	157	158	166	166	180	180	188	188	196	196	201	201	206	206	212	212	220	220
21	134	134	142	143	148	148	158	158	166	166	180	180	189	189	196	196	201	201	206	206	212	212	220	221
22	134	134	143	143	148	148	158	158	166	167	180	180	189	189	196	196	201	201	206	206	212	212	222	222
23	135	135	143	143	149	149	158	158	167	167	181	181	189	189	196	196	201	202	207	207	212	212	222	222
24	135	135	143	143	149	149	159	159	167	167	181	181	189	190	197	197	202	202	207	207	213	213	222	223
25	135	135	143	143	149	149	159	159	167	167	181	181	190	190	197	197	202	202	207	207	213	213	223	223
26	135	135	143	143	149	149	159	159	168	168	182	182	190	190	197	197	202	202	207	207	213	213	223	223
27	136	136	143	144	149	0	159	159	168	168	182	182	190	190	197	197	202	202	207	207	213	213	223	224
28	136	136	144	144	150	150	160	160	168	168	182	182	191	191	197	197	202	202	207	207	214	214	224	224
29	136	136	0	0	150	150	160	160	168	169	182	182	191	191	197	197	203	203	208	208	214	214	225	225
30	137	137	0	0	150	150	160	160	169	170	183	183	191	191	198	198	203	203	208	208	214	214	225	225
31	137	137	0	0	151	151	0	0	170	170	0	0	191	191	198	198	0	0	208	208	0	0	0	0

Table 4. OPA/Meppen Raw Data Tape Directory for 1978

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1	0	0	234	234	241	241	250	0	258	258	267	267	275	275	282	282	288	288	292	292	300	300	304	304
2	226	226	235	235	242	242	251	251	258	258	267	267	275	275	282	282	288	288	292	292	300	300	304	304
3	226	226	235	235	242	242	251	251	258	258	267	267	275	275	283	283	289	289	0	0	300	300	305	305
4	226	226	235	235	242	242	251	251	259	259	0	0	275	275	283	283	289	290	0	0	300	300	305	305
5	227	227	235	235	243	243	251	251	259	259	268	268	276	276	283	283	290	290	294	294	300	300	305	305
6	227	227	235	236	243	243	251	0	259	259	268	268	276	276	283	283	290	290	294	294	300	301	305	305
7	227	0	236	236	243	243	0	0	259	260	268	268	276	276	283	283	290	290	294	294	301	301	306	306
8	0	228	236	236	243	243	0	0	260	260	269	269	276	276	284	284	290	290	294	294	301	301	306	306
9	228	228	237	237	244	244	252	252	260	260	269	269	276	277	284	284	290	290	294	294	301	301	306	306
10	228	229	237	237	244	244	252	252	260	260	269	269	277	277	284	284	290	290	294	295	301	301	306	306
11	229	229	237	237	244	244	252	252	261	261	270	270	277	277	284	284	290	290	295	295	301	301	306	306
12	229	229	237	238	245	245	253	253	261	261	270	270	277	277	284	284	290	290	296	296	301	301	307	307
13	229	229	238	238	245	245	253	253	261	261	270	270	278	278	285	285	290	290	296	295	301	301	307	307
14	229	229	238	238	245	245	253	253	261	262	270	271	278	278	285	285	290	290	296	296	302	302	307	307
15	229	230	238	238	245	245	253	253	262	262	271	271	278	278	285	285	290	0	296	296	302	302	307	307
16	230	230	238	238	245	246	253	0	262	262	271	271	278	278	285	285	0	0	296	296	302	302	307	307
17	230	230	238	238	246	246	254	254	262	262	271	271	278	278	286	286	0	291	296	296	302	302	308	308
18	230	230	238	238	246	246	254	254	263	263	272	272	279	279	286	286	291	291	297	297	302	302	308	308
19	231	231	238	238	246	247	254	254	263	263	272	272	279	279	286	286	291	291	297	297	302	302	308	308
20	231	231	239	239	247	247	255	255	263	263	273	273	279	279	286	286	291	291	297	297	302	302	308	308
21	231	231	239	239	247	247	255	255	264	264	273	273	279	279	286	286	291	291	297	297	302	302	309	309
22	231	232	239	239	247	247	255	255	264	264	273	273	279	279	287	287	291	291	298	298	302	303	309	309
23	232	232	240	240	248	248	256	256	264	264	273	273	280	280	287	287	291	291	298	299	303	303	309	309
24	232	232	240	240	248	248	256	256	264	264	273	0	280	280	287	287	291	292	299	299	303	303	309	309
25	232	232	240	240	248	248	256	256	265	265	0	0	281	281	287	287	292	292	299	299	303	303	309	309
26	233	233	241	241	249	249	256	256	265	265	274	274	281	281	287	287	292	292	299	0	303	303	309	0
27	233	233	241	241	249	249	257	257	0	0	274	274	281	281	288	288	292	292	0	0	303	304	310	310
28	234	234	241	241	249	249	257	257	0	0	274	274	281	281	288	288	292	292	0	0	304	304	311	311
29	234	234	0	0	249	249	257	257	266	266	274	275	281	281	288	288	292	292	300	300	304	304	311	311
30	234	234	0	0	250	250	258	258	266	266	275	275	282	282	288	288	292	292	300	300	304	304	311	311
31	234	234	0	0	250	250	0	0	266	266	0	0	282	282	288	289	0	0	300	300	0	0	311	311

Table 5. OPA/Meppen Raw Data Tape Directory for 1979

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1	311	311	318	318	324	324	332	332	339	339	341	341	342	342	348	348	349	349	351	351	0	0	0	0
2	312	312	318	318	324	324	332	332	339	339	341	341	343	343	348	348	349	349	351	351	0	0	0	0
3	312	312	318	318	325	325	332	333	339	339	341	341	343	344	348	348	349	350	351	351	0	0	0	0
4	313	313	318	319	325	325	333	333	339	339	341	341	344	344	348	348	350	350	351	351	0	0	0	0
5	313	313	319	319	326	326	333	333	339	339	341	341	344	344	348	348	350	350	351	351	0	0	0	0
6	313	313	319	319	326	326	333	333	339	339	341	341	344	344	348	348	350	350	351	351	0	0	0	0
7	313	313	319	319	326	326	333	333	339	339	341	341	344	344	348	348	350	350	351	352	0	0	0	0
8	313	313	320	320	326	326	334	334	339	339	341	341	344	344	349	349	350	350	352	352	0	0	0	0
9	313	314	320	320	326	326	334	334	340	340	341	341	0	0	349	349	350	350	352	352	0	0	0	0
10	314	314	320	320	327	327	334	334	340	340	341	341	0	345	349	349	350	350	352	352	0	0	0	0
11	314	314	321	321	327	327	334	334	340	340	341	341	345	345	349	349	350	350	352	352	0	0	0	0
12	314	314	321	321	327	327	334	334	340	340	341	341	345	345	349	349	350	350	352	352	0	0	0	0
13	314	314	321	321	327	327	334	334	340	340	341	341	345	345	349	349	350	350	352	352	0	0	0	0
14	314	315	321	321	328	328	335	335	340	340	341	341	345	0	349	349	350	350	352	352	0	0	0	0
15	315	315	321	321	328	328	335	335	340	340	341	341	346	346	349	349	350	350	352	352	0	0	0	0
16	315	315	321	321	328	328	335	335	340	340	341	341	346	347	349	349	350	350	352	352	0	0	0	0
17	315	315	321	321	329	329	335	335	340	340	341	341	347	347	349	349	350	350	352	352	0	0	0	0
18	315	315	322	322	329	329	336	336	340	340	341	341	347	347	349	349	350	350	352	352	0	0	0	0
19	315	315	322	322	329	329	336	0	340	340	341	0	0	0	349	349	350	350	352	352	0	0	0	0
20	0	0	322	322	329	329	0	0	340	340	342	342	0	0	349	349	350	350	352	352	0	0	0	0
21	316	316	322	322	330	330	337	337	340	340	342	342	0	0	349	349	350	350	352	352	0	0	0	0
22	316	316	323	323	330	330	337	337	340	340	342	342	0	0	349	349	350	350	352	352	0	0	0	0
23	316	316	323	323	330	330	337	337	340	340	342	342	0	0	349	349	350	350	352	352	0	0	0	0
24	316	316	323	323	330	330	337	337	340	340	342	342	0	0	349	349	350	351	352	352	0	0	0	0
25	317	317	323	323	330	330	338	338	340	340	342	342	348	348	349	349	351	351	352	352	0	0	0	0
26	317	317	323	323	331	331	338	338	340	340	342	342	348	348	349	349	351	351	352	352	0	0	0	0
27	317	317	323	324	331	331	338	338	340	340	342	342	348	348	349	349	351	351	352	352	0	0	0	0
28	317	317	324	324	331	331	338	338	341	341	342	342	348	348	349	349	351	351	352	352	0	0	0	0
29	317	317	324	324	331	331	338	338	341	341	342	342	348	348	349	349	351	351	352	352	0	0	0	0
30	318	318	0	0	331	331	339	339	341	341	342	342	348	348	349	349	351	351	352	0	0	0	0	0
31	318	318	0	0	332	332	0	0	341	341	0	0	348	348	349	349	0	0	0	0	0	0	0	0

Table 6. OPA/Meppen Raw Data Tape Directory for 1980

I.3 DATA LOGGER SYSTEM PERFORMANCE

Another use of the Raw Data Tape Directories is in determining the percentage of data logger system "off-line" time on a monthly or yearly basis. Viewed in this way, and using December, 1976 as the starting month for the OPAQUE measurement program, the following table summarizes both monthly and yearly performance through December, 1980.

Table 7. Percentage of OFF-LINE Time, Monthly and Yearly

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEARLY
1976	----	----	----	----	----	----	----	20.9	1.67	35.5	23.3	4.83	27.45
1977	46.7	10.7	19.4	8.33	1.61	6.67	12.9	9.67	10.0	16.1	0.00	8.06	12.6
1978	20.9	0.00	1.61	0.00	0.00	8.33	0.00	12.9	0.00	1.61	0.00	11.3	4.79
1979	6.45	0.00	0.00	11.7	6.45	8.33	0.00	0.00	6.67	14.5	0.00	1.61	4.66
1980	3.22	0.00	0.00	5.00	0.00	1.66	25.8	0.00	0.00	0.00	11.6	11.3	4.92

A detailed analysis of the data logger recording time on an hourly or minute basis can be carried out using the data tape timing information contained in the system file, TAPEFILE (the raw data tape log file).

Considering the fact that the data logger system is operated continuously in an unattended mode, the yearly percentage of "down-time" is quite remarkable for the total period of operation given above. The majority of the daily outages can be attributed to losses of power at the field site and reaching an end of tape condition on the magnetic tape recorder. The remaining outages can be attributed to periods of hardware maintenance or system software and hardware modifications to accommodate changes in the types and number of experimental sensors.

An interesting interpretation of these statistics is to view them as a learning curve of the personnel operating the field site at Meppen. After becoming familiar with the operational characteristics of a fully automated data logger, the yearly tape directories show extended periods of continuous operation broken by several half days

of outages which suggests increasing operational familiarity and confidence. The use of design techniques that minimize operator intervention to a "reload and restarting of the system" significantly reduces accidental system interruptions and results in an operational procedure that can be taught very quickly to new operators of the system.

A copy of the current data logger control programs in use at the U.S. OPAQUE Field Station in Meppen, West Germany is included as an appendix to this report.

I.4 SENSOR PERFORMANCE LIBRARY

While the information provided in a OPA/Meppen Raw Data Tape Directory can be used to determine whether the data logger was operational during a specific time period, it is not descriptive of the individual sensor performance. The Sensor Performance Library is maintained and formatted to provide this information on a yearly basis as the examples in Figures 1. and 2. demonstrate. The yearly directories provide a copy of the PROFILE program output and the HISTOGRAM program output for each raw data tape. Providing this information on a per tape basis yields an estimate of all sensor performances on essentially one hour intervals for most data tapes. It should be noted that these programs normally scan the raw data tape to determine the start and finish times of the recording period, which is not constant as can be seen in Tables 2 through 6 above. The complete Sensor Performance Directories for the years 1977, 1978, 1979, and 1980 are provided as separately bound supplements to this report.

The DATA PROFILE Tape Directories display all of the active data sensors sampled using the mnemonic designators listed in Section I.1 along the ordinate and the time of day along the abscissa. The directory also gives the starting and ending time of the raw data tape, along with the total number of minutes of recorded data and the number of minutes represented by each abscissa time division. The data designators, A-U and $ or *, represent the average value of the channel sensor taken over the abscissa time division interval. In reading the directories, one can determine very quickly the average performance of a given sensor by noting if the data designator * (over-range, usually interpreted as meaning the channel is not active) or $ (meaning the data value is negative and not usable) is displayed over any portion of the plot. Use of these plots is in millivolts and reflect the discrete nature of the analog-to-digital voltage conversion which has a resolution of 2.5 millivolts per count.

A (0- 247)	B (250- 497)	C (500- 747)	D (750- 997)
E (1000-1247)	F (1250-1497)	G (1500-1747)	H (1750-1997)
I (2000-2247)	J (2250-2497)	K (2500-2747)	L (2750-2997)
M (3000-3247)	N (3250-3497)	O (3500-3747)	P (3750-3997)
Q (4000-4247)	R (4250-4497)	S (4500-4747)	T (4750-4997)
U (5000)	* (> 5000)	$ (negative)	

The HISTOGRAM PROFILE Directories display all of the active data sensors using the mnemonics listed in Section I.1 along the ordinate and the raw data sensor voltage range, (-5 volts to +5 volts), along the abscissa. The information displayed is generated during the execution of the control program AUTOHEX, which also produces the DATA PROFILE plots. Whereas the DATA PROFILE plots average the channel voltage values over the designated time division interval of the plot, the HISTOGRAM PROFILE plots count the total number of data channel values that fall within each 100 millivolt increment to generate the histograms. While the total presentation in the HISTOGRAM PROFILE plot is essentially a "top-down" view of each of the individual data channel histograms, the detail given for each data channel allows a rapid determination of normal or abnormal activity of the experimental sensor assigned to that channel. The right-most column in the plot gives the total number of data points counted per channel over the duration of the raw data tape. A comparison of the total number of minutes (at the top of the plot) with the total number of data points counted on a data channel known to be sampled at one minute intervals does reveal some discrepancies in that the total "run" time of the raw data tape may be larger. This is due to the fact that the total run time is calculated from the start and stop times of the raw data tape and if out of range "time tags" are detected during the processing, the data samples associated with those "bad" times are collected and displayed in the last line of the plot labeled as 0038-00. This line also contains all of the one minute sample points taken on channels 31, 32, 33, and 34 that are not displayed in the HISTOGRAM (and the PROFILE plot also) plot in order to keep the plot on one computer printer page (usually 66 lines).

The HISTOGRAM PROFILE designator scale used in these plots is listed below. The numerical values assigned each designator are

percentages of the total number of data points listed at the right side of the plot for each sensor.

- (0 - 4%)	A (5 - 9%)	1 (10 - 14%)	B (15 - 19%)
2 (20 - 24%)	C (25 - 29%)	3 (30 - 34%)	D (35 - 39%)
4 (40 - 44%)	E (45 - 49%)	5 (50 - 54%)	F (55 - 59%)
6 (60 - 64%)	G (65 - 69%)	7 (70 - 74%)	H (75 - 79%)
8 (80 - 84%)	I (85 - 89%)	9 (90 - 94%)	J (95 - 99%)
* (100%)			

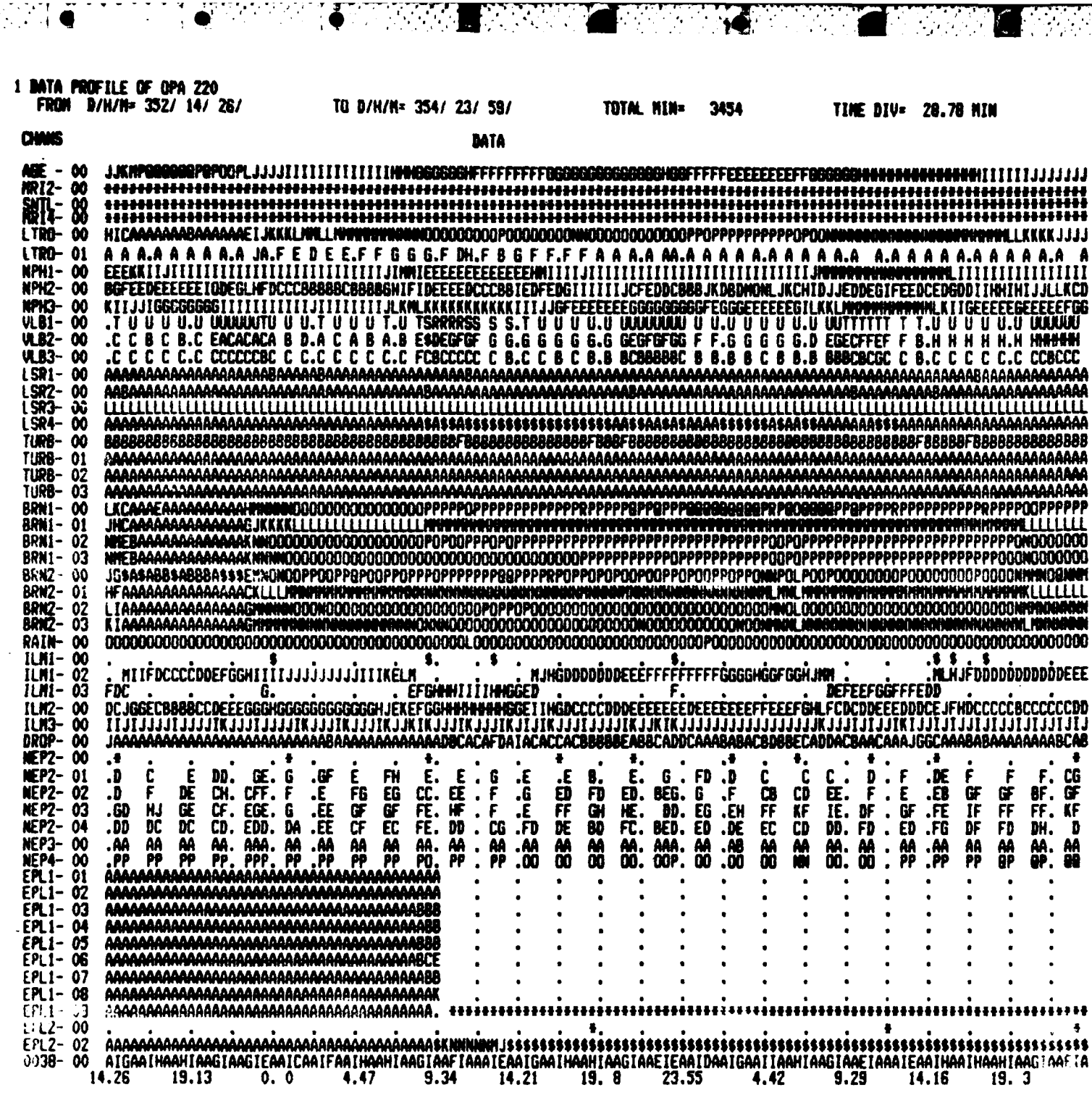


Figure 1. Example of Data Profile Plot

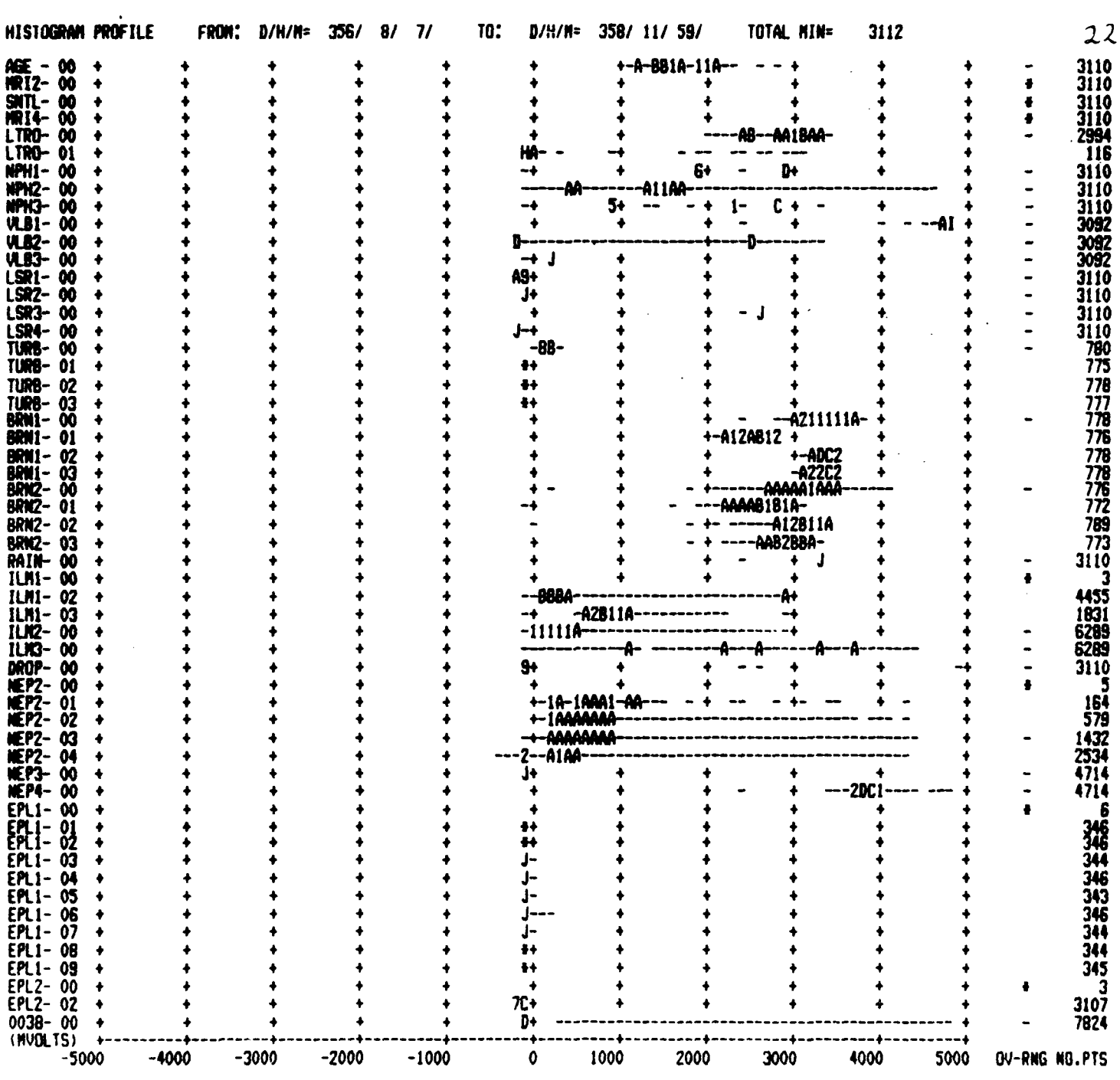


Figure 2. Example of Histogram Profile Plot

I.5 STRIPPED DATA TAPE LIBRARY

The execution of the procedure files with the raw data tapes produce output files that consist of formatted data samples stored as half-day records for a whole month of data. These stripped data files are then stored on magnetic tape, packed three months to a tape. This stripped data base is stored on magnetic tapes issued, catalogued, and housed at the A.F.G.L. Computer Center. Table 8A., the Computer Center (CC) Stripped Data Tape Directory, lists all of the active CC tapes by tape number and the data interval represented.

Due to the time and effort required in generating the stripped data tapes, and the possibilities for program or human error in processing the data contained on these tapes, a double or backup copy of each CC stripped data tape is generated and stored by the ULowell contractor. Table 8B., the Backup (OPA) Stripped Data Tape Directory, lists all of the active backup tapes by tape number and the data interval represented.

Table 8A. Computer Center (CC) Stripped Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	2898	2898	3213	3213	3213	3325	3325	3325	2726	2726	2726	2842
1978	2842	2720	2720	2720	0766	0766	0766	1442	1442	1442	1417	1417
1979	1417	0003	0003	0003	0009	0009	0009	3885	3885	3885	3908	3908
1980	3908	4287	4287	4287	4518	4518	4518	2904	2904	2904		

Table 8B. Backup (OPA) Stripped Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	971	971	951	951	951	955	955	955	956	956	956	954
1978	954	957	957	957	958	958	958	959	959	959	960	960
1979	960	961	961	961	962	962	962	963	963	963	964	964
1980	964	965	965	965	967	967	967	970	970	970		

II.1 USER'S MANUAL FOR STRIPPING AND OUTPUT PACKAGES

A manual entitled User's Manual for Stripping and Output Package of the NATO Project OPAQUE U.S.A.F. System Control Programs was prepared to accompany the final report (1978). This manual describes the commands necessary to generate the stripped minute channel files, luxmeter files, and vislab files from the raw data tape files and generate plots and tabulated data from these stripped files. Also the commands necessary to generate the Erik files from the stripped files are described.

II.2 CALIBRATION PACKAGE OUTPUT

Yearly calibration files have been generated to process the raw data. These calibration files are routine which generate calibrated scientific values from the raw data for any particular instrument. For some instruments, the calibration data applies for specific periods in the year, and the date has to be supplied to determine the proper calibration formulas to be used.

As each calibration package has been completed, test data showing scientific values corresponding to the raw data values for each instrument under all different possible conditions has been generated and made available to the experimenters to check. This calibration data and a listing of the FORTRAN calibration subroutines was prepared into a report for the year 1977. Comparable calibration packages for the subsequent years 1978, 1979, and 1980 will be reported under separate cover.

II.3 DESIGN OF CO2 LASER SOFTWARE PACKAGE

The CO2 laser data is processed into a separate monthly file generated from data contained in the stripped minute channel files.

II.3.1 LASERFILE Structure

The structure of the monthly LASERFILE is illustrated in Figure 3. The file is for a 31 day period corresponding to a single monthly stripped minute array file. The file consists of 93 records (3x31 days). Each 24 hour period day uses three records. The first of these is a single word which is the start time in seconds for that day from the beginning of the year + 86400 seconds. The second and third are the angle and laser scattering data respectively for each minute of the 24 hour period; hence the first word of record 2 and the first word of record 3 are the angle and corresponding scattering data for the first minute of the 24 hour period starting at the time stored in record 1. Note that the monthly record generally doesn't correspond to a particular yearly month, nor does the start time correspond to the first hour of the day.

The LASERFILE is first initialized in a separate procedure (INLASER). The time records (1, 4, 7,...) are set to the appropriate time in seconds as determined from input data. The laser data records (2, 3, 5, 6, 8, 9,...) are initialized to -1.E.30.

Each monthly LASERFILE requires 1400 PRUs of mass storage. The file is a sequential (rather than a random access) file and, as such, requires care in manipulating.

II.3.2 Reconstructing the Angle Function

The laser instrument has a sensor which measures the scattering from a laser beam as shown in Figure 4. The scattering sensor sweeps back and forth at constant velocity through an angle of 160° as shown.

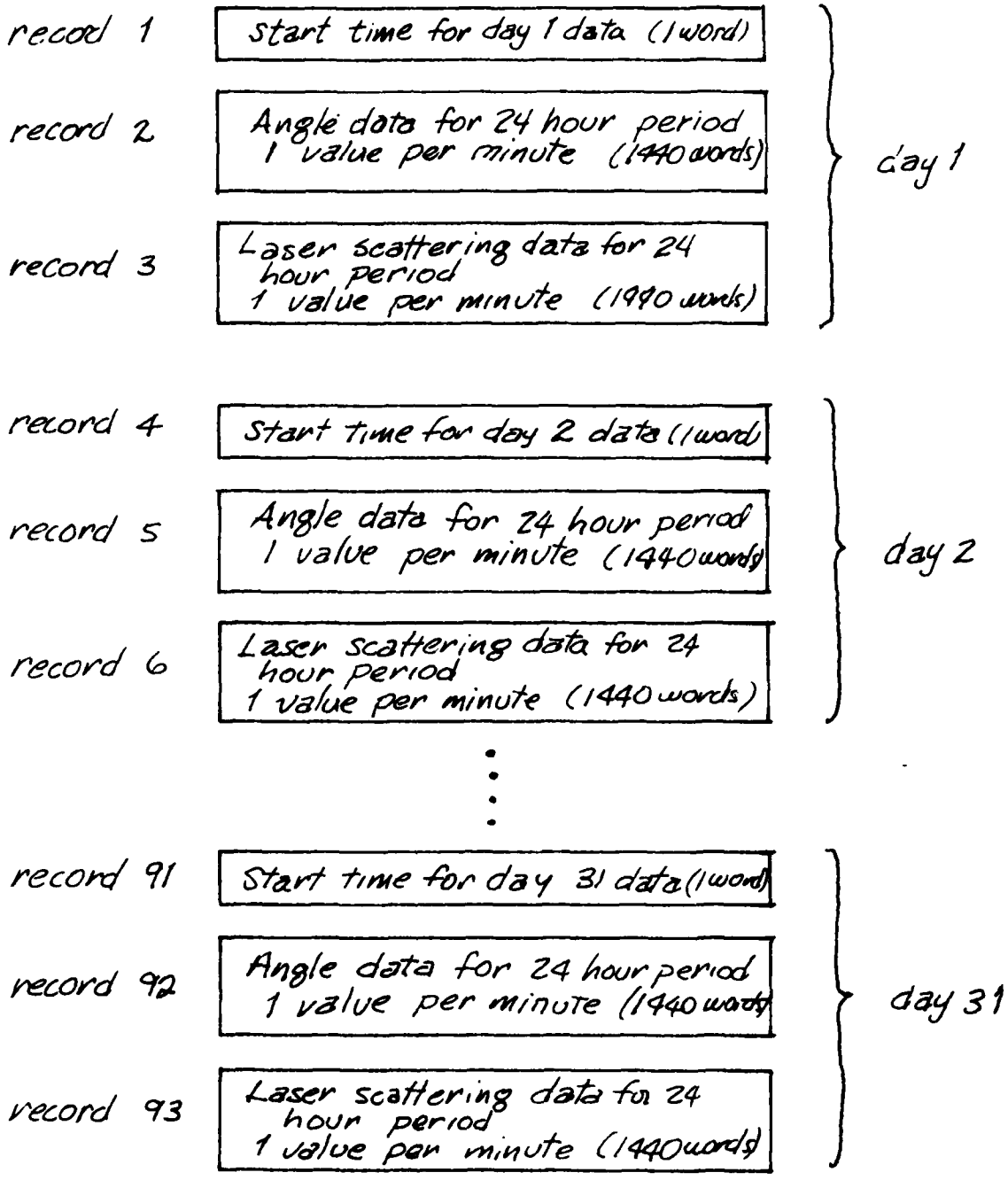


Figure 3. Laserfile Structure

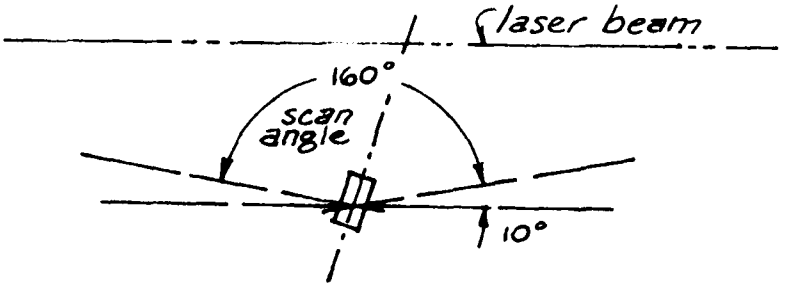


Figure 4. Laser Instrument Scan Angle

A problem occurred with the angle sensor which required some involved programming. Apparently a set screw loosened on the angle sensor so that the angle measured was significantly different than the actual angle. In some cases the angle measurement saturated so that only the lower part of the angle as a function of time was retrievable from the raw data. Fortunately there is sufficient data to reconstruct the angle function. Basically the technique for doing this is to estimate the times at which the angle reaches its minimum position and use this data to reconstruct the actual angle for a given time.

An array of 12 time values (in seconds from the beginning of the year + 86400) is generated (if possible) for a given half-day record of the stripped minute channels. This array represents the best estimates of the time at which the minimum angles during each sweep occurred.

The algorithm for doing this is as follows:

i) the half-day record is searched from the beginning for each occurrence of the condition in the laser angle shown in Figure 5.

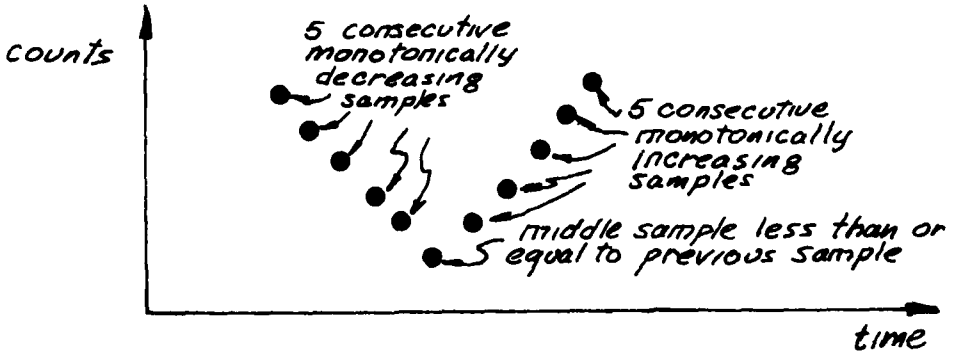
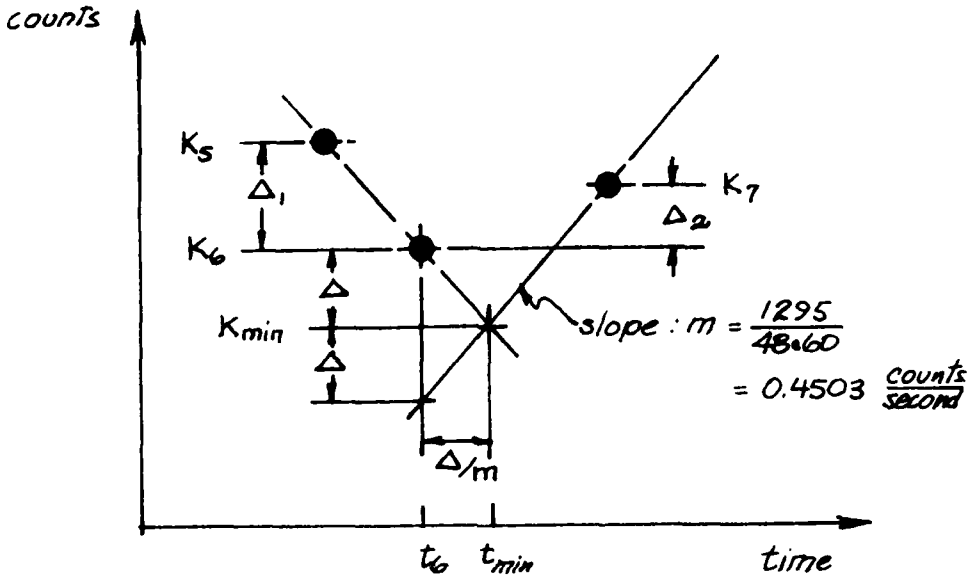


Figure 5. Condition for Possible Minimum Angle

When 11 consecutive samples are found that meet this condition, it is taken to indicate a possible minimum point in the angle signal, and the estimate of the time and the actual angle is calculated using the 5th, 6th, and 7th samples of the set according to the equations developed in Figure 6. The estimated times are stored in an array.



From geometry:

$$\Delta_1 = \Delta_2 + 2\Delta$$

or $$\Delta = \frac{1}{2}(\Delta_1 - \Delta_2)$$

$$t_{min} = t_6 + \frac{\Delta}{m} = t_6 + \frac{\Delta_1 - \Delta_2}{2(.0.4503)}$$

but $$\Delta_1 - \Delta_2 = K_5 - K_7$$

and $$\boxed{t_{min} = t_6 + 1.1115\,(K_5 - K_7)}$$

The minimum angle is (from calibration):

$$A_{min} = 0.1235\ K_{min} + 2.6^\circ$$

but $$K_{min} = K_6 - |\Delta|$$

so $$\boxed{A_{min} = 0.1235\left(K_6 - \frac{1}{2}|K_5 - K_7|\right) + 2.6^\circ}$$

Figure 6. Algorithm for Minimum Angle Determination

ii) Tests are made on the resulting array. In particular if the scan period between successive minima was less than 5400 seconds or greater than 6200 seconds, a message is printed. Also if only one minimum point or more than 10 is found for a half-day record, these too are indicated.

iii) In order to make the array useful before the first sample and after the last, the array (if it passes the above tests) is extrapolated to include one or two false minima before the first point and after the last. This is done by calculating an average scan period using the good points. Also obvious missing minima values are added using the same average period.

iv) After the array is generated, the results are printed out. This includes the following for each minimum (including the extrapolated ones):

a) A list of times at which the minima occurred both in seconds after the beginning of the year (+86400) and in days, hours, minutes, and seconds;

b) the estimated angles for each of the times. If the times were extrapolated or reconstructed, the corresponding angle printed out is -999.00;

c) an indicator of the condition of the minimum. These values are possibly -9, 1, or 0:

-9 indicates an extrapolated or reconstructed minimum,

1 indicates a minimum was found and for at least 3 of the 11 points used, the gain measurement was not at its maximum value,

0 indicates a minimum was found and the gain condition for a "1" was not met;

d) the difference in time (the period) between consecutive minima in seconds.

A sample printout showing the generated minima is given in Figure 7. From the array of generated minimum times, the angle can be constructed. The algorithm for this is shown in Figure 8.

II.3.3 Summary of LASERFILE Processing

The processing necessary to construct the LASERFILE from a monthly stripped minute file requires the following steps:

1) The monthly LASERFILE is initialized with the procedure INLASER.
2) The stripped minute channel is scanned for preliminary data using the procedured SCAN. This essentially generates a printout of the angle minima (as described above) for the entire month.
3) Using the information from the scan, all possible data is extracted and put into the LASERFILE using the procedure PROCESS. Data can only be extracted over those periods where a continuous set of angle minima have been obtained. This procedure catalogs a new cycle of the initialized LASERFILE; the old one can be purged.
4) Time plots and scatter plots are generated from the stripped minute channels over those periods where the gain signal left its maximum value (i.e., the indicator described above took on the value 1). Periods when this didn't occur indicates that the laser was not properly charged, and the data is not generally useful. The procedures LTPLOT and LSPLOT do this. Sample plots are shown in Figures 9. and 10.
5) Finally, a map of the LASERFILE is made using the procedure MAP. A sample LASERFILE map is shown in Figure 11. Each pair of lines represents a two hour period. The top line corresponds to the angle and the bottom, the scattering value. Generally, a letter is used for the angle except where the gain is not at its maximum value. There a letter is changed to a digit; A becomes 1, B, 2, etc. The lower line uses letters if the scattering value is negative and digits if positive. / denotes no raw data exists, - denotes the data is bad, and $ denotes the scattering value is zero.

CHANNEL 17 (P) BOTTOM = 1.[illegible]E+06 TOP = 6.[illegible]E+06 EACH DIVISION = 5.[illegible]E+05
CHANNEL 17 (N) BOTTOM = 1.46 TOP = 1.56 EACH DIVISION = 1.00(E-02
POSSIBLE MIN SPACING PROBLEM

MINS GENERATED

9536277	110/ 9/57/57	-999.00	-9	
9542101	110/11/35/ 1	114.68	0	5824
9547925	110/12/12/ 5	117.02	0	5824
9553726	110/13/48/46	-999.00	-9	5801
9554880	110/14/ 8/ 0	115.05	1	1154
9560666	110/15/44/26	108.25	1	5786
9566472	110/17/21/12	108.38	1	5806
9572267	110/18/57/47	108.56	1	5795
9578063	110/20/34/23	108.50	1	5796
9583864	110/22/11/ 4	-999.00	-9	5801
9589665	110/23/47/45	-999.00	-9	5801

MINS GENERATED

9576056	110/20/34/16	-999.00	-9	
9583852	110/22/11/52	109.30	1	5796
9589648	110/23/47/28	104.24	1	5796
9595433	111/ 1/23/53	104.67	0	5785
9601228	111/ 3/ 0/28	104.98	0	5795
9607020	111/ 4/37/ 0	104.86	0	5792
9612812	111/ 6/13/32	-999.00	-9	5792
9618604	111/ 7/50/ 4	-999.00	-9	5792

CHANNEL 16 (O) BOTTOM = 0. TOP = 250. EACH DIVISION = 25.0
POSSIBLE MIN SPACING PROBLEM

MINS GENERATED

9536277	110/ 9/57/57	-999.00	-9	
9542101	110/11/35/ 1	114.68	0	5824
9547925	110/12/12/ 5	117.02	0	5824
9553726	110/13/48/46	-999.00	-9	5801
9554880	110/14/ 8/ 0	115.05	1	1154
9560666	110/15/44/26	108.25	1	5786
9566472	110/17/21/12	108.38	1	5806
9572267	110/18/57/47	108.56	1	5795
9578063	110/20/34/23	108.50	1	5796
9583864	110/22/11/ 4	-999.00	-9	5801
9589665	110/23/47/45	-999.00	-9	5801

MINS GENERATED

9576056	110/20/34/16	-999.00	-9	
9583852	110/22/11/52	109.30	1	5796
9589648	110/23/47/28	104.24	1	5796
9595433	111/ 1/23/53	104.67	0	5785
9601228	111/ 3/ 0/28	104.98	0	5795
[illegible]	111/ 4/37/	104.86	0	5792
[illegible]	111/ 6/13/32	-999.00	-9	5792
[illegible]	111/ 7/50/ 4	-999.00	-9	5792

CHANNEL [illegible] (?) LOG SCALE . BOTTOM = 1 **(-12) TOP = 1.0**(-2)

Figure 7. Sample Printout Showing Generated Minima of Laser Angle

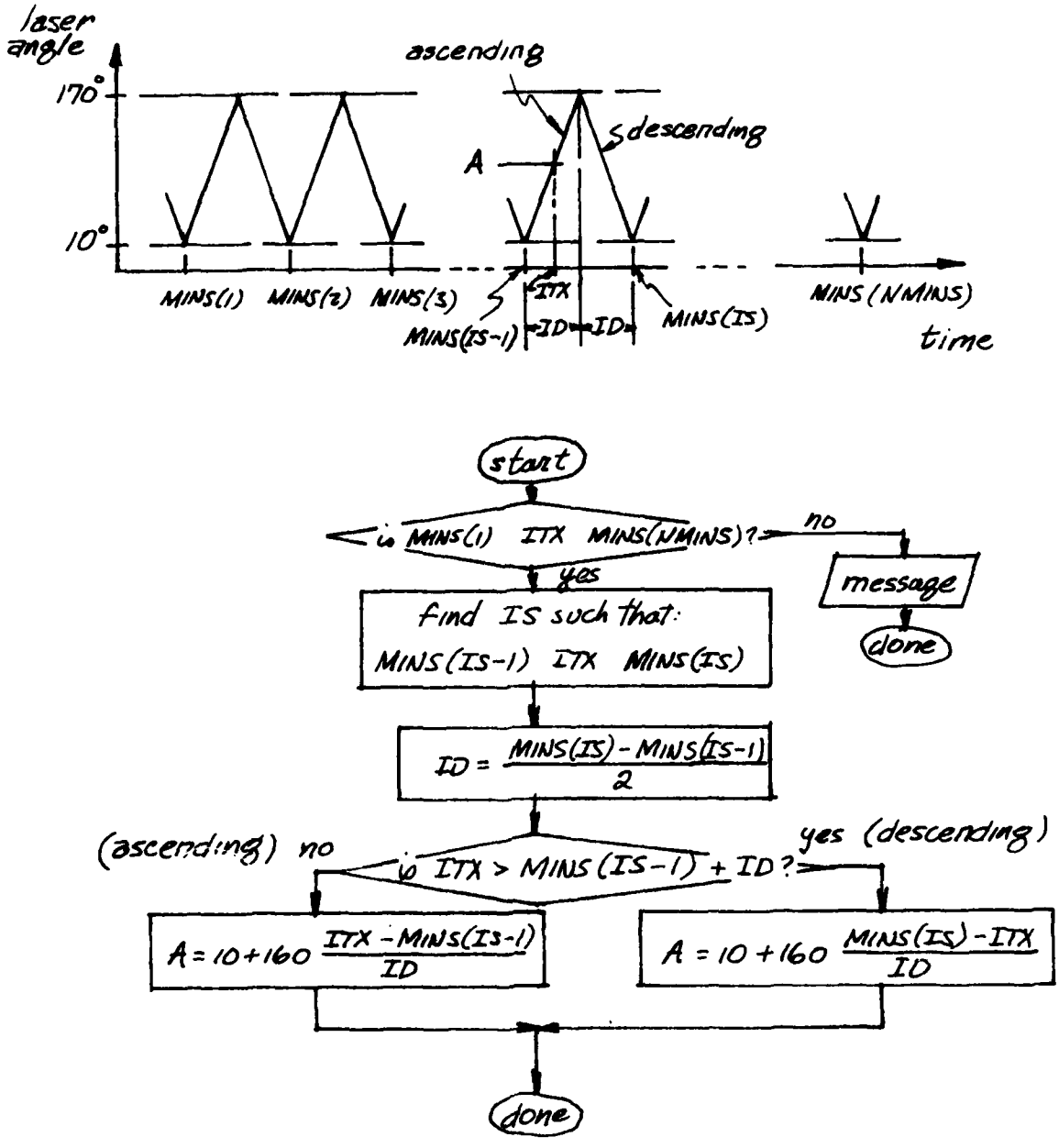


Figure 8. Algorithm For Angle Construction

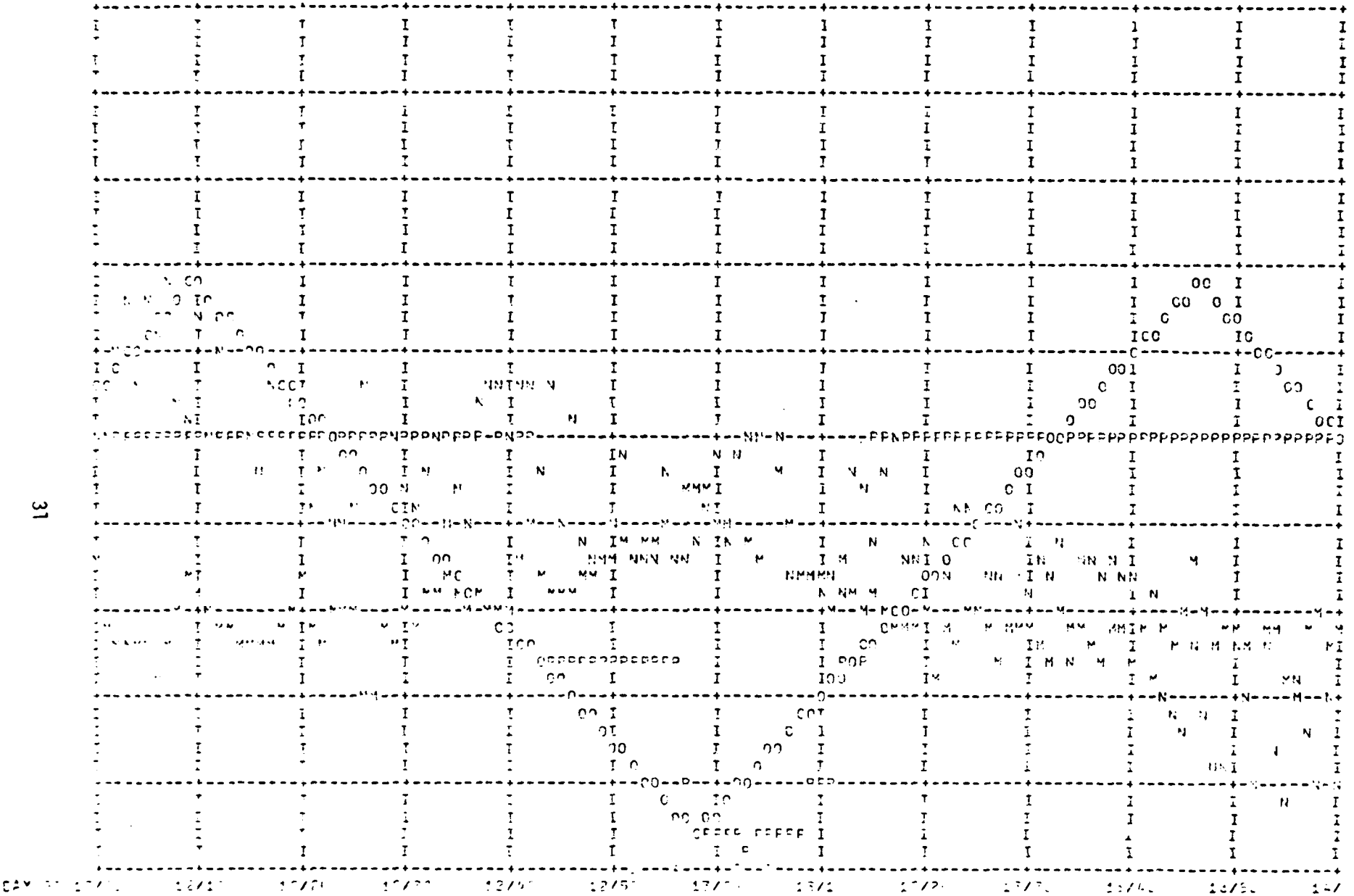


Figure 9. Laser Time Plot

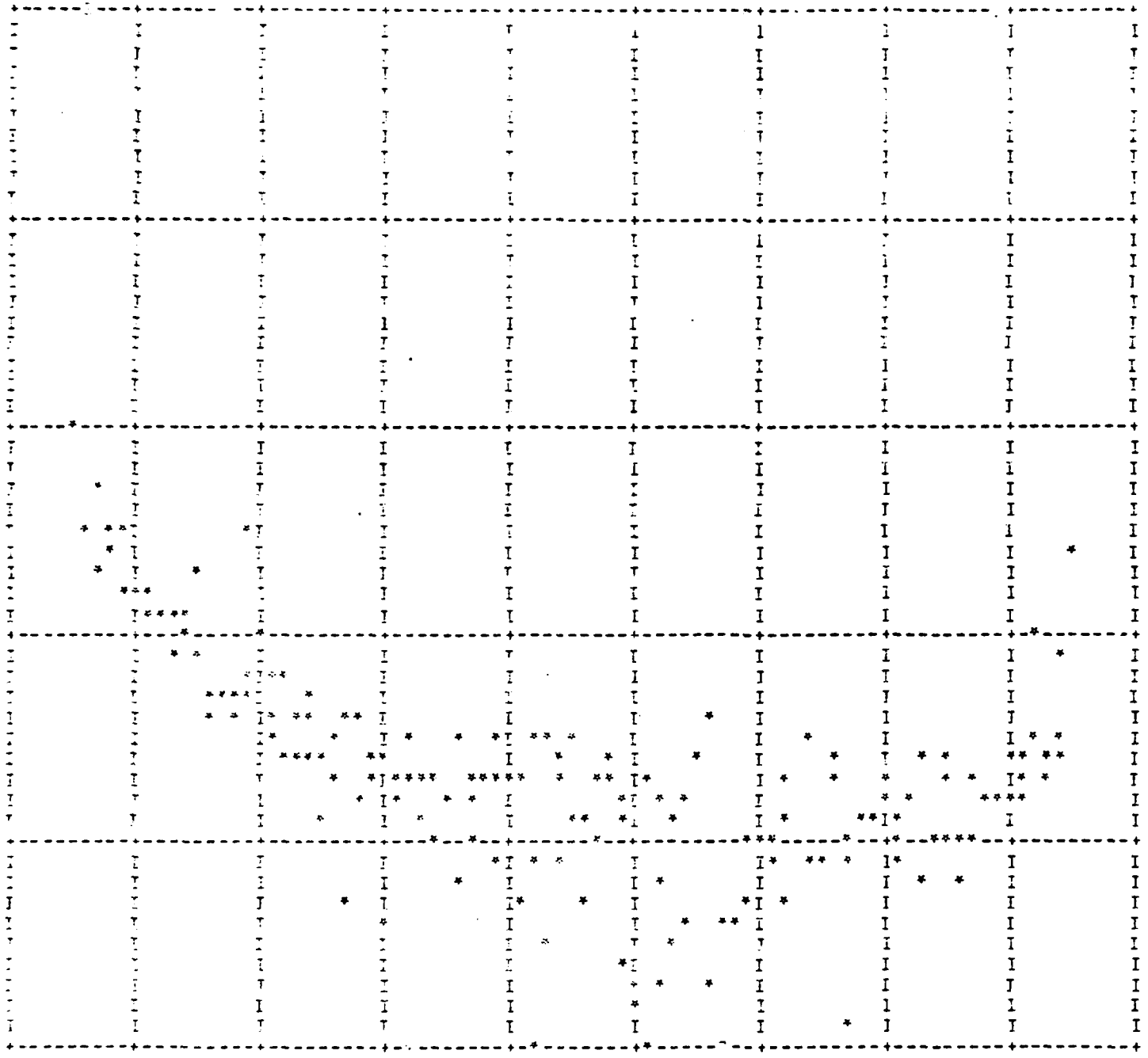


Figure 10. Laser Scatter Plot

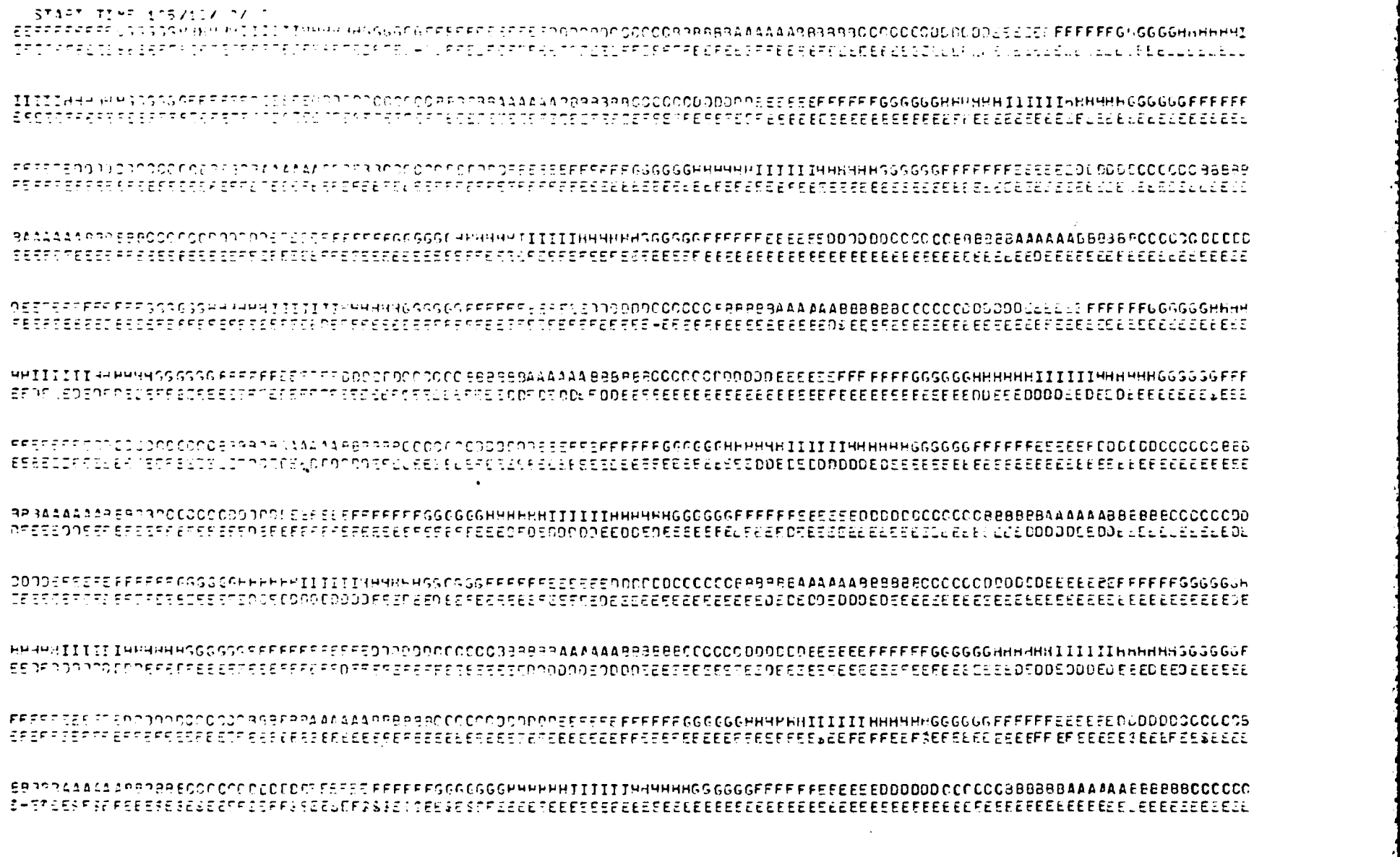


Figure 11. Laser File Map

II.4 CO2 LASER DATA TAPE DIRECTORY

The CO2 Laser data files that are produced by the software package described above are stored on magnetic tapes issued, catalogued, and housed at the A.F.G.L. Computer Center. Table 9., the Computer Center (CC) CO2 Laser Data Tape Directory, lists all of the active CC tapes by tape number and the data intervals represented.

Due to the time and effort required in generating these data tapes, and the possibilities for program or human error in processing the data contained on these tapes, a double or backup copy of each CC stripped data tape is generated and stored by the ULowell contractor. Table 10., the Backup (OPA) CO2 Laser Data Tape Directory, lists all of the active backup tapes by tape number and the data intervals represented.

Table 9. Computer Center (CC) CO2 Laser Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	2635	2635	2843	2843	2843	---	---	---	---	2843	2843	2843
1978	2843	2843	2843	2843	2843	2843	2843	2843	2843	2843	2843	2843
1979	---	---	---	---	2843	2843	2843	2843	2843	2843	---	---
1980	---	---	---	---	2843	2843	2843					

Table 10. Backup (OPA) CO2 Laser Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	920	920	921	921	921	---	---	---	---	921	921	921
1978	921	921	921	921	921	921	921	921	921	921	921	921
1979	---	---	---	---	921	921	921	921	921	921	---	---
1980	---	---	---	---	921	921	921					

Note: The months listed as --- represent periods when the instrument was not operational.

II.5 SCANNING NEPHELOMETER PROCESSING

II.5.1 General Considerations

The scanning nephelometer, like the laser instrument, scans back and forth through an angle of about 160°, completing one scan (back and forth) in about 200 seconds. The scan rate is approximately 1.6°/second. The instrument is sampled once per second for a 30 minute period on alternate hours. Data from the instrument requires 4 channels of the data logger:

Channel 31	Angle
Channel 32	Scale
Channel 33	Photopic
Channel 34	Monitor

In addition, the discrete on channel 32 contains two additional pieces of information. The most significant digit is the gain, and the least significant digit is the filter number (8 of them).

The nephelometer has an indexing filter which changes every scan (back and forth). Based on the Meppen log, the instrument was working essentially over these periods of time.

November 1976 - March 1977
January 1978 - August 1978
November 1978 - Present

The first and second periods were terminated when the xenon lamp exploded.

During the first period, the instrument was sampled each second for a twenty minute period every hour. This however, was not enough time to complete a cycle of eight scans (one for each filter), so the recording time was changed to thirty minutes every other hour.

The program which is described here is for processing this thirty minute data. The program requires modification to handle the twenty minute recording time.

II.5.2 The Nephelometer File Structure

The following nephelometer file structure is acceptable in terms of program core size, permanent file size, and tape file size.

The structure is shown in Figure 12. Basically one file in the structure corresponds to one raw data file. A thirty minute nephelometer recording period supplies the data for one record in this file. There may be up to 200 of these records in each file. In addition, the first record of the file is a file directory.

Each data record in the file consists of 3,620 words. The first 20 words contain information about the record (start time and filter information). The remaining 3,600 words contain the data (two words per second). The channel information is packed two channels per word in exactly the same form used for the stripped minute data files.

The size of the file varies according to the number of thirty minute periods contained on the raw data tape. For a four day raw tape period there would normally be 48 records (plus an additional record for the directory). This is equivalent to about 2,720 prus. The directory has been sized so the file can contain 200 records.

The total size for a complete month requiring say ten raw data tapes would be about 30,000 prus. (a convenient value for a disk pack or magnetic tape file) Hence, the completed nephelometer data file would require one magnetic tape per month. This is convenient in terms of the plots which are to be generated from the data. It is probably advisable to save files which overlap two months on each of the monthly magnetic tapes so that each would contain a full calendar month.

In addition to the nephelometer files, it is necessary to add a directory to each monthly magnetic tape file so that data for a particular time can be accessed from the tape. The structure of the month tape directory is also shown in Figure 12.

II.5.3 Nephelometer Stripping Program Results

A nephelometer stripping program was developed using the minute channel stripping program developed previously as a basis. A sample run was made in which a seven hour period was stripped from data tape OPA231. Samples of the contents of the stripped file are shown in Figures 13 and 14. The directory for the file is first displayed showing the start time for each of the seven stripped hours.

The record for the first hour is fetched and a list of the sample numbers of the entries corresponding to each of the 8 filters is printed, then a map showing a quantized representation of the angle profile for each of the 1800 samples is printed. The angle function is obvious from this map and the correspondence with the sample numbers at which each filter starts can also be seen. Finally, a display of the values for the first minute of the record are printed in tabular form (using the command SAMPLE,1,60). The first column is the sample number; the second column contains the gain discrete value; the third column is the filter number. The last four columns give the counts of channels, 31, 32, 33 and 34.

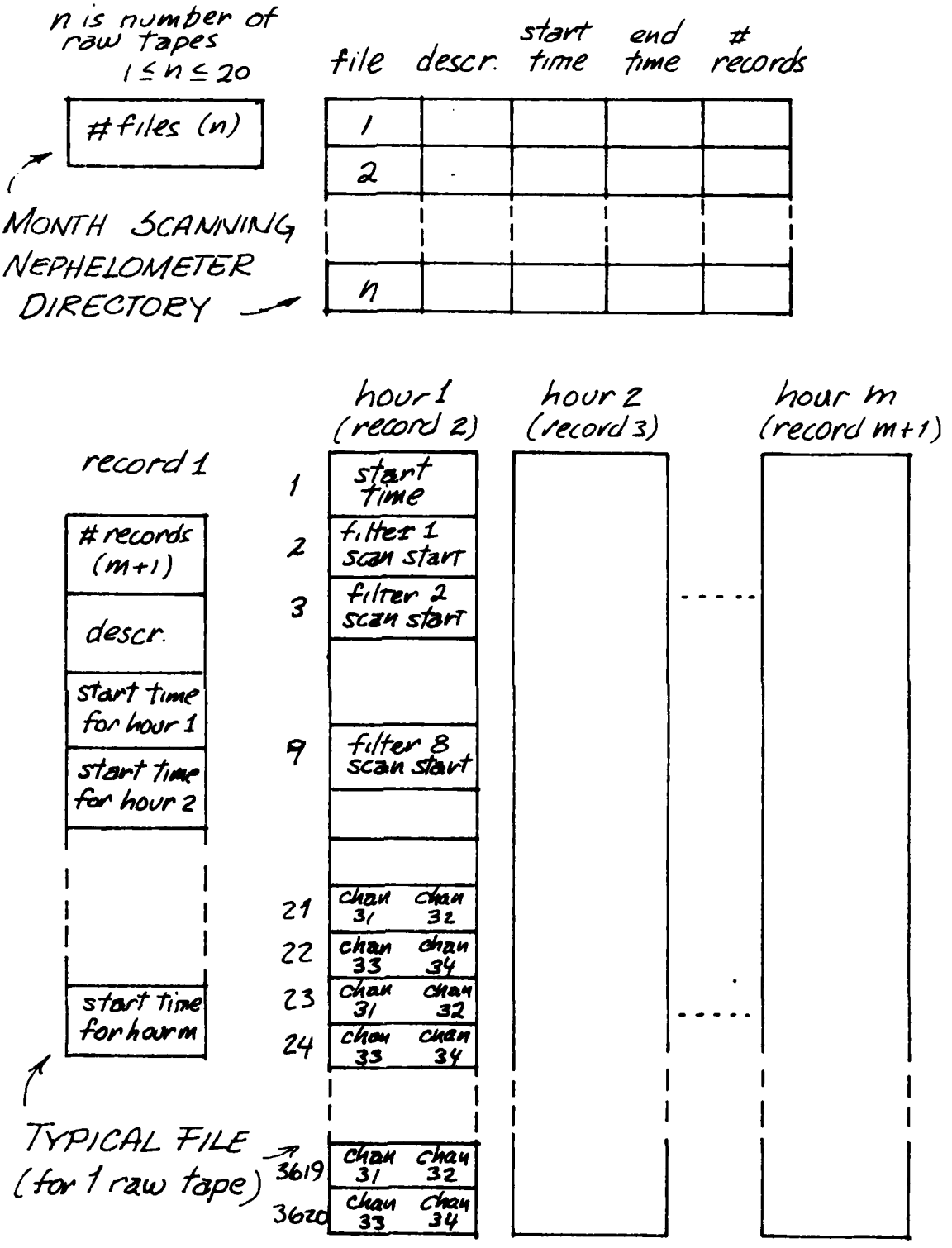


Figure 12. Scanning Nephelometer File (1 month)

```
   START OF NEPHELOMETER PROCESSING COMMANDS


   -DATA ARRAY KLEARED-

   EOF FOUND IN BLOCK    1
DIRECTORY

   -DIRECTORY-

   RAW231NEPH INITIALIZED FOR   7 HOURS    8 RECORDS

   START TIMES -

        HOUR   1      19/11/ 0/ 0
        HOUR   2      19/13/ 0/ 0
        HOUR   3      19/15/ 0/ 0
        HOUR   4      19/17/ 0/ 0
        HOUR   5      19/19/ 0/ 0
        HOUR   6      19/21/ 0/ 0
        HOUR   7      19/23/ 0/ 0

GET,13CON

   -GOT RECORD FOR HOUR   1  START TIME IS  19/11/ 0/ 0


   -CONTENTS-

START TIME -  19/11/ 0/ 0
   FILTER 0    SAMPLE  220
   FILTER 1    SAMPLE  421
   FILTER 2    SAMPLE  624
   FILTER 3    SAMPLE  825
   FILTER 4    SAMPLE 1026
   FILTER 5    SAMPLE 1227
   FILTER 6    SAMPLE 1429
   FILTER 7    SAMPLE   29

SAMPLE,1,60
```

Figure 13. Nephelometer Processing Output

SAMPLE	GAIN	FILT	CHAN 31	CHAN 32	CHAN 33	CHAN 34
1	4	6	1562	231	7	953
2	INVALID					
3	4	6	1585	229	5	954
4	4	6	1606	231	0	953
5	4	6	1611	243	5	963
6	4	6	1631	212	7	972
7	4	6	1657	237	6	970
8	4	6	1674	249	6	963
9	4	6	1691	270	5	969
10	4	6	1717	275	7	965
11	4	6	1721	260	5	962
12	4	6	1745	296	6	958
13	4	6	1768	306	5	956
14	4	6	1790	331	7	965
15	4	6	1805	384	5	957
16	4	6	1827	391	5	958
17	4	6	1845	455	5	964
18	4	6	1849	503	8	973
19	4	6	1835	445	6	964
20	4	7	1617	578	6	964
21	4	7	1705	765	5	964
22	4	7	1763	768	6	960
23	4	7	1755	774	6	957
24	4	7	1737	729	6	954
25	4	7	1717	695	6	950
26	4	7	1689	637	6	961
27	4	7	1671	624	6	950
29	4	7	1655	615	6	951
29	4	7	1635	584	6	952
30	4	7	1609	542	7	960
31	4	7	1595	544	6	953
32	4	7	1575	531	6	951
33	4	7	1555	504	6	949
34	4	7	1529	479	6	943
35	4	7	1517	478	6	941
36	4	7	1491	462	6	939
37	4	7	1479	451	6	936
39	4	7	1451	456	6	945
39	4	7	1437	454	6	936
40	4	7	1417	447	5	938
41	4	7	1397	433	5	940
42	4	7	1373	435	5	953
43	4	7	1355	446	5	945
44	4	7	1349	448	7	941
45	INVALID					
46	4	7	1299	453	5	944
47	4	7	1275	473	6	942
48	4	7	1257	453	7	939
49	4	7	1233	446	6	937
50	4	7	1211	477	5	946
51	4	7	1191	490	6	936
52	4	7	1177	496	7	940
53	4	7	1159	492	6	942
54	4	7	1131	495	5	957
55	4	7	1117	501	6	950
56	4	7	1099	526	6	954
57	4	7	1079	536	6	957
58	4	7	1051	547	5	955
59	4	7	1037	547	6	953
60	4	7	1017	547	6	950

DONE

Figure 14. Nephelometer Data for One Minute

II.6.1 Low Visibility Data File Structure

The Low Visibility Data File contains the following entries for each minute:

1. Time (in minutes after the beginning of the year).
2. An integer which is either:
   i) a positive value which indicates the filter used on the BARNES instrument for that minute. If the ELTRO instrument was used for the extinction coefficient, the filter number is 1, 2, 3, 5, or 6. If the AEG instrument was used to obtain the extinction coefficient, 10 is added to the filter number so that it is either 11, 12, 13, 15, or 16.

      Filter numbers use the OPAQUE convention as follows:

1	3-5 microns
2	8-12 microns
3	8-13 microns
5	open
6	4 microns

   ii) A negative value:

      a) -1 to -5 which indicates that data could not be obtained for that minute. The negative number entered indicates the reason as follows:

-1	extinction data not available
-2	extinction data not valid
-3	BARNES data not available
-4	BARNES filter number not valid
-5	BARNES data not valid.

      Tests are made in the above order; only the first cause of failure is reported.

b) -9 which indicates that the visibility was above the threshold (and passed the above tests) and that instrument data was not entered in 3 and 4 below.

3. The extinction coefficient obtained from the ELTRO instrument if it is available; otherwise from the AEG instrument data.
4. The BARNES transmission data for the filter indicated in entry 2.

I entry 2 is negative indicating instrument data has not been entered in 3 or 4, the value -999.9 is entered there instead.

The threshold value for the visibility is 3 km which corresponds to an extinction coefficient of 1.304 km^{-1}. The visibility if lower than this value approximately 20% of the time. The file contains continuous time so that data is present in only about 20% of the file; simplicity was felt to be more important than efficient file space.

The first record (ILVD) contains integer values (entries 1 and 2); the second (RLVD) contains real values (entries 3 and 4). Each of these records is dimensioned 2 x 720 (since there are 720 minutes in 12 hours). A file usually contains 62 pairs of these half-day records. Hence, data is arranged as shown in Figure 15.

With this sizing, records contain 1440 words. Two records (2880 words) must appear in core at the same time. Hence files contains 2 x 1440 x 62 / 64 = 2790 PRUs. Tapes can contain 12 files (33480 PRU's) conveniently, so a total of 3 tapes would be generated for the approximately 3 years of data. The data tapes generated for the U.S. Army ASL use usually contain one month of data for convenience.

II.6.2 Low Visibility Data Generation Algorithm

In processing the minute files to generate the low visibility data files, the method for obtaining the extinction coefficient is described below.

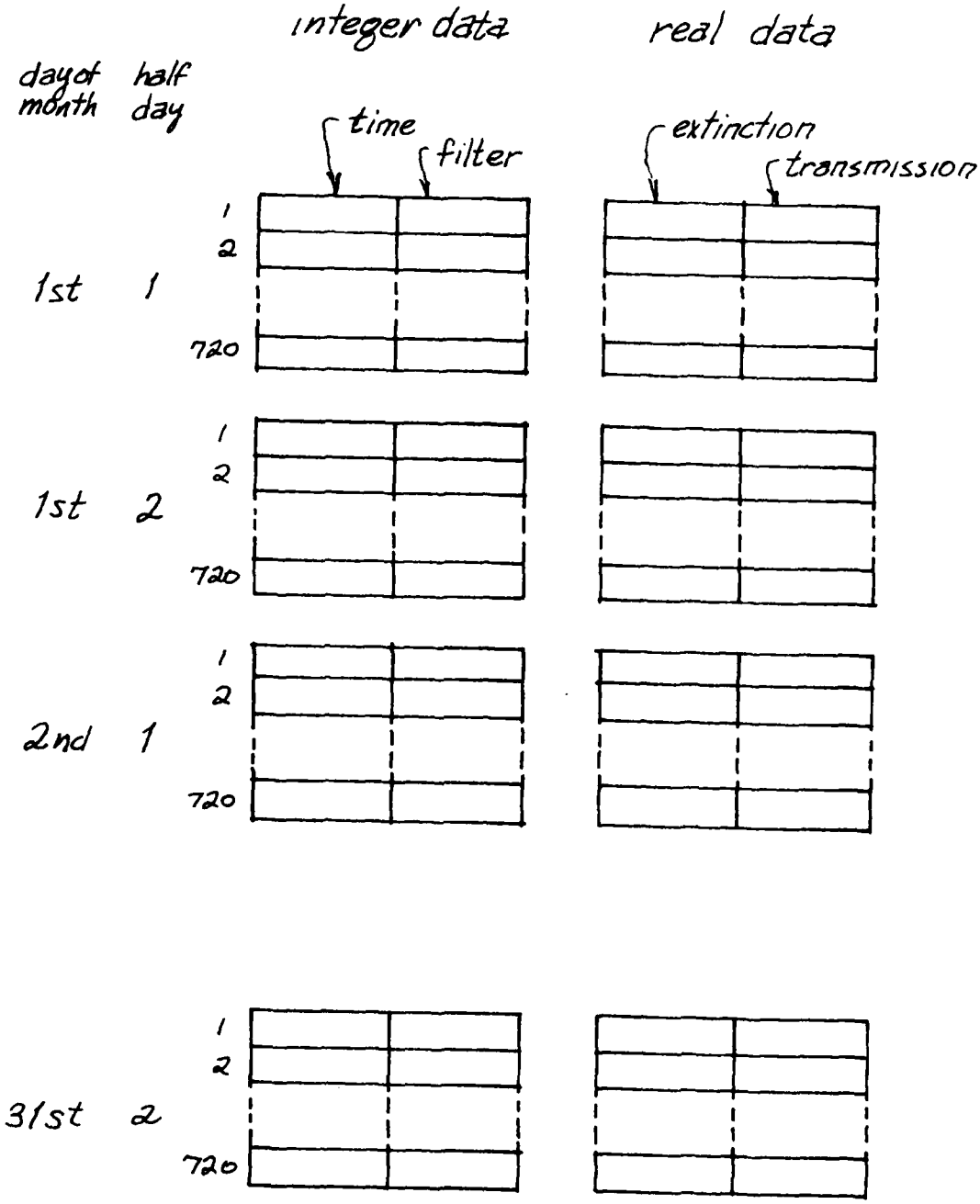


Figure 15. Low Visibility Data File Arrangement

If the ELTRO instrument was operating at the time, then that data is used for the extinction coefficient. If, however, that data is not valid or the ELTRO was not in operation at the time, then the AEG instrument is used if available and valid. The ELTRO instrument signal changed to a calibration mode for 2 or 3 minutes approximately 32 minutes after the start of each hour. If the visibility was below the threshold in the data 3 or 4 minutes previous to the occurrence of the calibration signal, then the data at that time was accepted as low visibility data. No extinction value is given in the data (the value -999.9 appears) at the time of ELTRO calibration.

II.6.3 Low Visibility Data Map Program

A map is generated for each file which gives an indication of every entry in the file. A sample map is shown in Figure 16. Each strip of 6 lines shows all the data for a two hour period. The first line of data is an indication of the extinction coefficient. The four lines following indicate values for the BARNES transmission for the filter indicated in the leftmost column.

Symbols used are as follows:

EXTINCTION COEFFICIENT:

-	data not able to be obtained for that minute,
/	data available but above low visibility threshold,
A-Z	indicates value of extinction coefficient value (see Figure 17.),
blank	indicates calibration signal on Eltro channel.

BARNES TRANSMISSION:

A-Z	indicates transmission value on a scale of 0 to 100% (see Figure 17.).

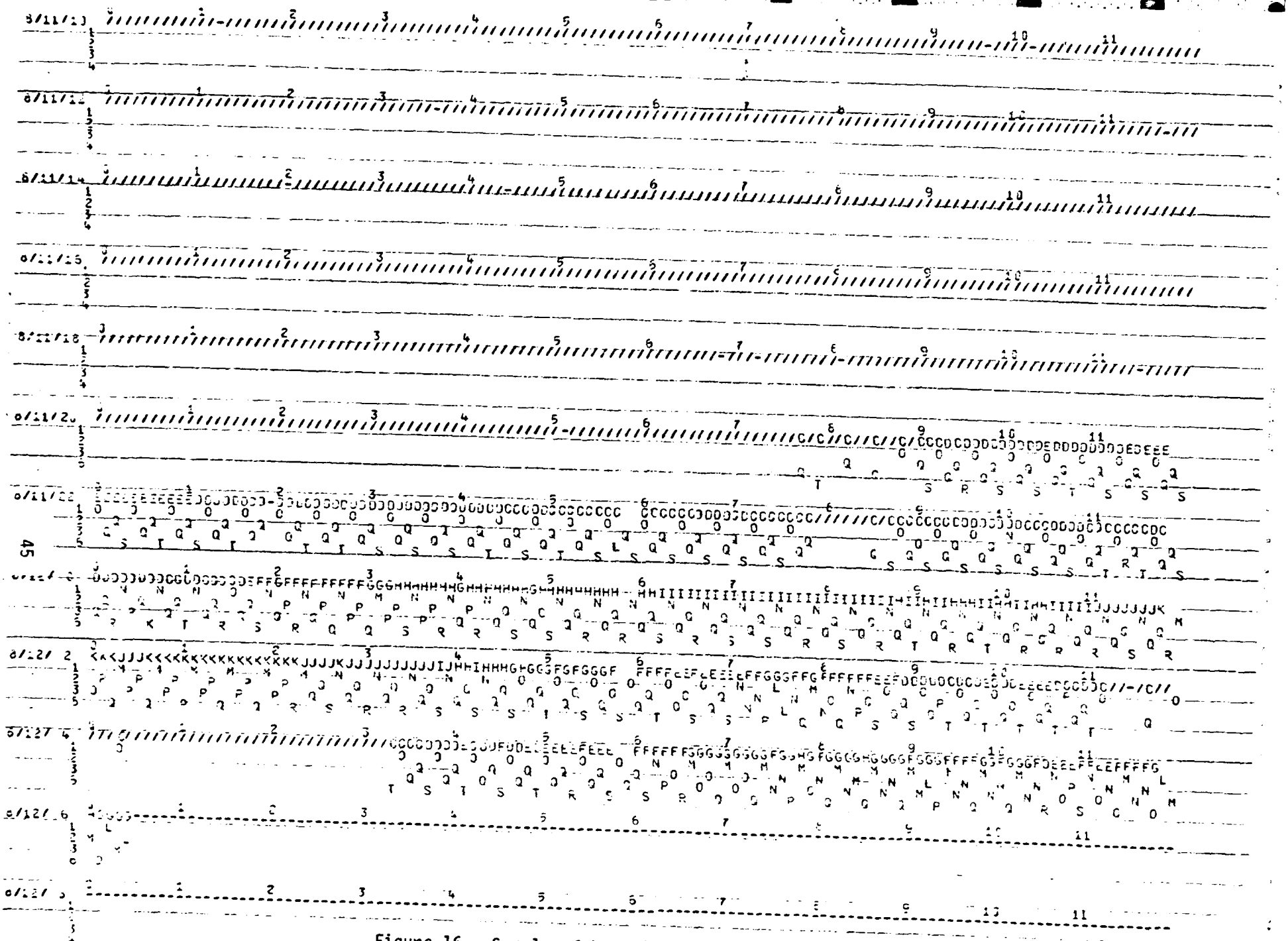
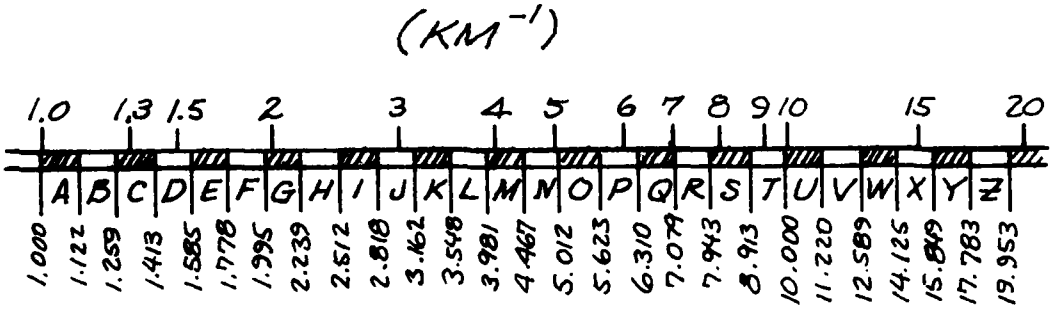
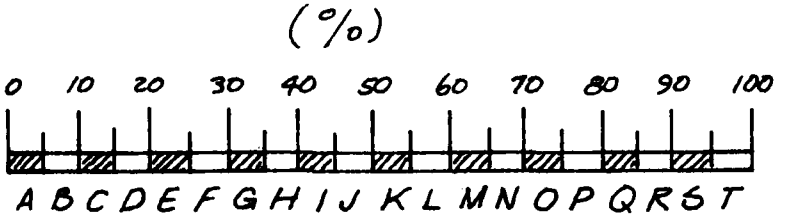


Figure 16. Sample of Low Visibility Data File Map



MAP QUANTIZATION - EXTINCTION COEFFICIENT



MAP QUANTIZATION - BARNES TRANSMISSION

Figure 17. Map Quantization

II.6.4 Low Visibility Data Printout Program

A program has been written for printout out data stored in the Low Visibility Data Files for selected periods of time. A sample is shown in Figure 18.

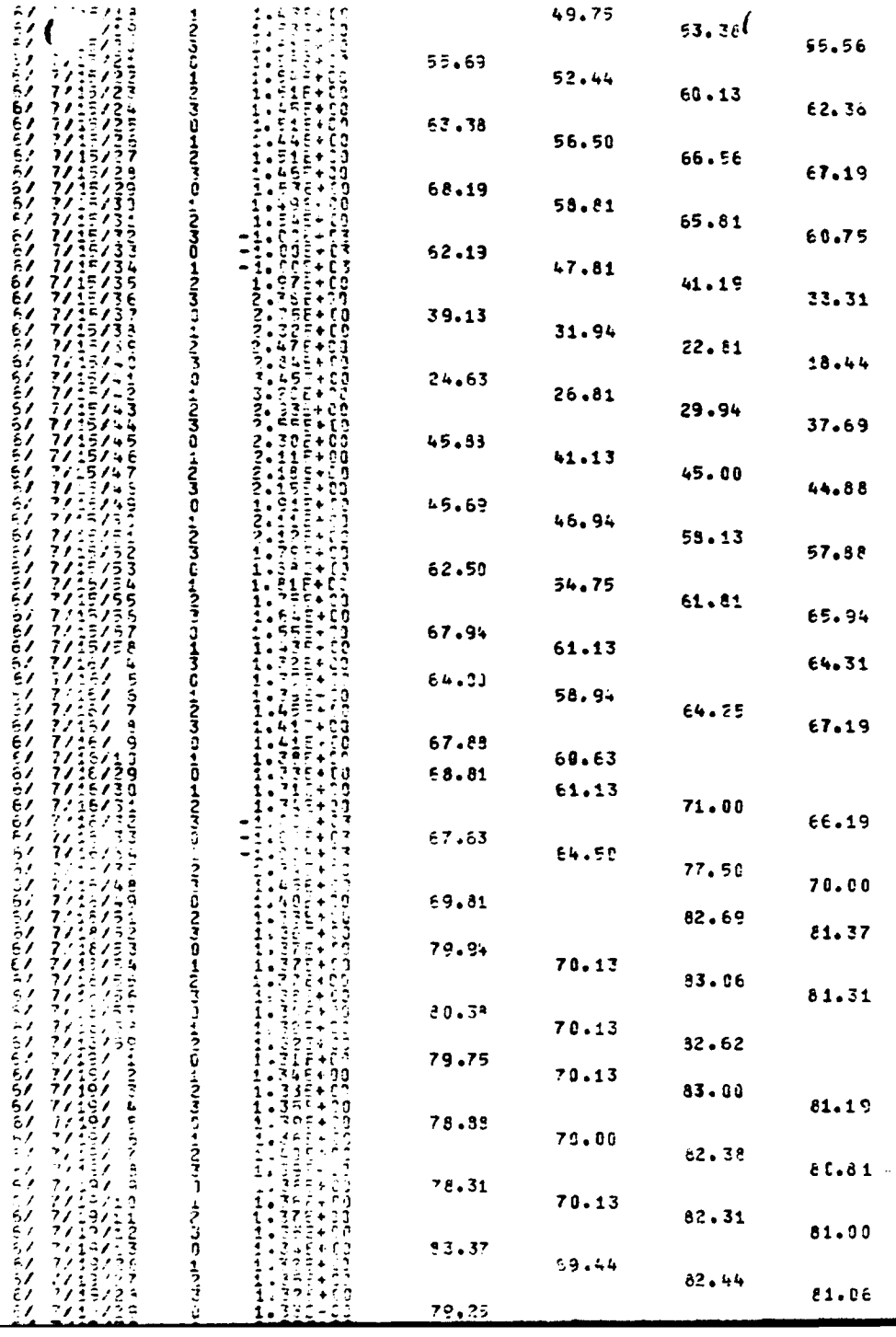


Figure 18. Low Visibility Data Printout Sample

II.7 LOW VISIBILITY DATA TAPE DIRECTORY

The Low Visibility data files that are produced by the software package described above are stored on magnetic tapes issued, catalogued, and housed at the A.F.G.L. Computer Center. Table 11., the Computer Center (CC) Low Visibility Data Tape Directory, lists all of the active CC tapes by tape number and the data intervals represented.

However, after some experience with this data set, it was found that the short runtime of the software procedure file and the need for data sets with and without the selection "window" allows rapid regeneration of either data set eliminating the backup tape requirement.

Table 11. Computer Center (CC) Low Visibility Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977			3213	3213	3213	3325	3325	3325	2726	2726	2726	2882
1978	2842	2720	2720	2720	0766	0766	0766	1442	1442	1442	1417	1417
1979	1417	0003	0003	0003	0008	0008	0009	3885	3885	3885	3908	3908
1980	3908	4287	4287	4287	4518	4518	4518					

Table 12. Backup (OPA) Low Visibility Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977			0025	0034	0032	0931	0927	0033			0038	
1978			0123	0874	0743	0756	0757	0769	0777	0782	0417	0418
1979	0862	0875	0873	0115	0317	0312						

II.8.1 Description of the ERIK File

The ERIK file is a one-month file containing 31 records, one for each day of the month. For months containing less than 31 days, the extra records are merely disregarded. Each daily record contains an array dimensioned 85 x 24. There are 85 entries for each hour of the day, the entries being derived from a 10 minute period during the hour.

The data entries reported for each hour are defined in Table 13., Format of the Hourly OPAQUE Data Bank File. The 85 entries are initialized as follows:

1.	(station number) 71
2.	(date) year, month, day, packed into the 6 rightmost digits
3.	(time) hour (0,1,2,...23)
4.	(duration of measurement cycle) 10
5-10.	(comments and scattering-filter-humidity) 0
11-57.	(measurement values) $-1 \times 10^{+30}$
58-77.	(weather data) $-1 \times 10^{+30}$
78-84.	(data quality) appropriate number of 9's
85.	(rain data) $-1 \times 10^{+30}$

With the exceptions of entries 76 and 85 (rainfall data), entries 58 thru 85 are not recorded by the measurement system data logger. They are added after the processing described in this paper by an entirely separate process by A.F.G.L. which is outside the scope of this contract.

The processing of measurement values are of several types:

1. The MRI Photopic channel, Eltro, Horizontal Luxmeter, Night Path Luminance, and the east direction VPFM require the beginning value, end value, max value, min value, and number of samples obtained in the 10 minute period.

Table 13. Format of the Hourly OPAQUE Data Bank File

Data File Word No.	Data Item	Measurement	Data Logger Channel
1	Station No.	= 71	
2	Date - Year,Month,Day		
3	Time		
4	Duration of Measurement Cycle	010	
5	Comment Numbers		
6	" " "		
7	" " "		
8	" " "		
9	" " "		
10	Scattering x 100 + Filter x 10 + Humidity		
11	S_s BEG		
12	S_s FIN		
13	S_s MAX	AEG Point Visibility Meter	0
14	S_s MIN		
15	NV	Number of Measurements	
16	E_g BEG		
17	E_g FIN		
18	E_g MAX	Eltro Transmissometer	4
19	E_g MIN		
20	NV		
21	E_L BEG		
22	E_L FIN		
23	E_L MAX	Horizontal Luxmeter	24
24	E_L MIN		
25	NV		
26	E_v^N (North)		
27	E_v^E (East		
28	E_v^S (South)	Vertical Luxmeter	25 (compass points from 26)
29	E_v^W (West)		

Table 13. Format of the Hourly OPAQUE Data Bank File (Cont)

Data File Word No.	Data Item	Measurement	Data Logger Channel
30	L_p^{NT} BEG		
31	L_p^{NT} FIN		
32	L_p^{NT} MAX	Night Path Luminance	6 (with 5 & 7)
33	L_p^{NT} MIN		
34	NV		
35	F_p^E BEG		
36	F_p^E FIN		
37	F_p^E MAX	Vis. Lab. Variable Path Function Meter	11 (Directions from 12)
38	F_p^E MIN		
39	NV		
40	F_p^S		
41	F_p		
42	F_p^N		
43	E_o^1	λ = 0.945	36 f = 1
44	E_o^2	λ = 0.4	36 f = 2
45	E_o^3	λ = 0.87 Eppley Filtered	36 f = 3
46	E_o^4	λ = 1.06	36 f = 4
47	E_o^5	λ = 0.75	36 f = 5
48	E_o^6	λ = 0.55	36 f = 6
49	E_o^7	photopic	36 f = 7
50	E_o^8	λ = 0.3 to 0.5	37 BEG
51	E_o^9	Direct Eppley	
52	E_o^{10}	λ = 0.3 to 0.5	37 FIN

Table 13. Format of the Hourly OPAQUE Data Bank File (Cont)

Data File Word No.	Data Item	Measurement	Data Logger Channel		
			Before Day 96 1977	Days 96-145 1977	After Day 145 1977
53	T_1	3-5μm BEG	f = 0	-	f = 1
54	T_2	8-12μm Barnes Transmissometer (500m)	f = 3	f = 3	f = 3
55	T_3	8-13μm	f = 2	f = 2	f = 2 Channel 21
56	T_x	Open or 4μm	f = 1	-	f = 0
57	T_8	3-5μm FIN	f = 0	-	f = 1
58	X				
59	A				
60	B	Aerosol Data			
61	C				
62	D				
63	E				
64	F	3-5μm Barnes Transmissometer (500m)		22	
65	G	8-12μm			
66	H				
67	I	Turbulence Data			
68	N	Cloud Cover			
69	dd	Wind Direction at 10 m			
70	ff	Wind Speed at 10 m			
71	d_2d_2	Wind Direction at 2 m			
72	f_2f_2	Wind Speed at 2 m			
73	ppp^2	Pressure			
74	TTT	Temperature			
75	$T_dT_dT_d$	Dew Point Temperature			
76	rrr	Rain Rate		23	
77	E	General Ground State			

Table 13. Format of the Hourly OPAQUE Data Bank File (Cont)

Data File Word No.	Data Item	Measurement	Data Logger Channel
78	QQQQ	Packed MR1 Data Quality	
79	QQQQ	Packed Eltro Data Quality	
80	QQQQQQQQ	Packed Luxmeter Data Quality	
81	QQQQ	Packed Night Path Data Quality	
82	QQQQQQQ	Packed Vis Lab Data Quality	
83	QQQQQQQQQQ	Packed Eppley Data Quality	
84	QQQQQ	Packed Barnes Data Quality	
85	RRR	Total Rain for past hour	23 (Total Rain)

2. The vertical Luxmeter requires one value from each of the four compass points.
3. The VPFM samples in the south, west, and north compass points are required in addition to the 5 values above for the east direction.
4. The direct Eppley and Barnes instrument require values entered, depending on the filter being used for the measurement.

All data values are entered into the daily arrays except if the value was not physically present, or the data could not be interpreted, or the data was out of range, and then a distinguishable flag value is entered in its place. Hence, if a scientific value is not entered for one of these reasons, one of the following values will be entered in its place:

$-1 \times 10^{+30}$	raw data for that time does not exist;
$-9 \times 10^{+99}$	raw data exists, but it is impossible to interpret;
$+8 \times 10^{+88}$	the calibrated scientific value is out-of-range (too large);
$-8 \times 10^{+88}$	the calibrated scientific value is out-of-range (too small).

II.8.2 Overview of the ERIK File Generating Process

An overview of the programs used to generate and examine the ERIK files is shown in Figure 19. The boxes show the permanent files involved, and the directed lines show the procedures necessary to accomplish the task.

Before the values can be placed in the ERIK file, it must be initialized with the INERIK procedure. The initial values have been listed previously.

The ERIK file is generated from the three stripped data file: The Stripped Minute Channel File, the Stripped Luxmeter File, and the

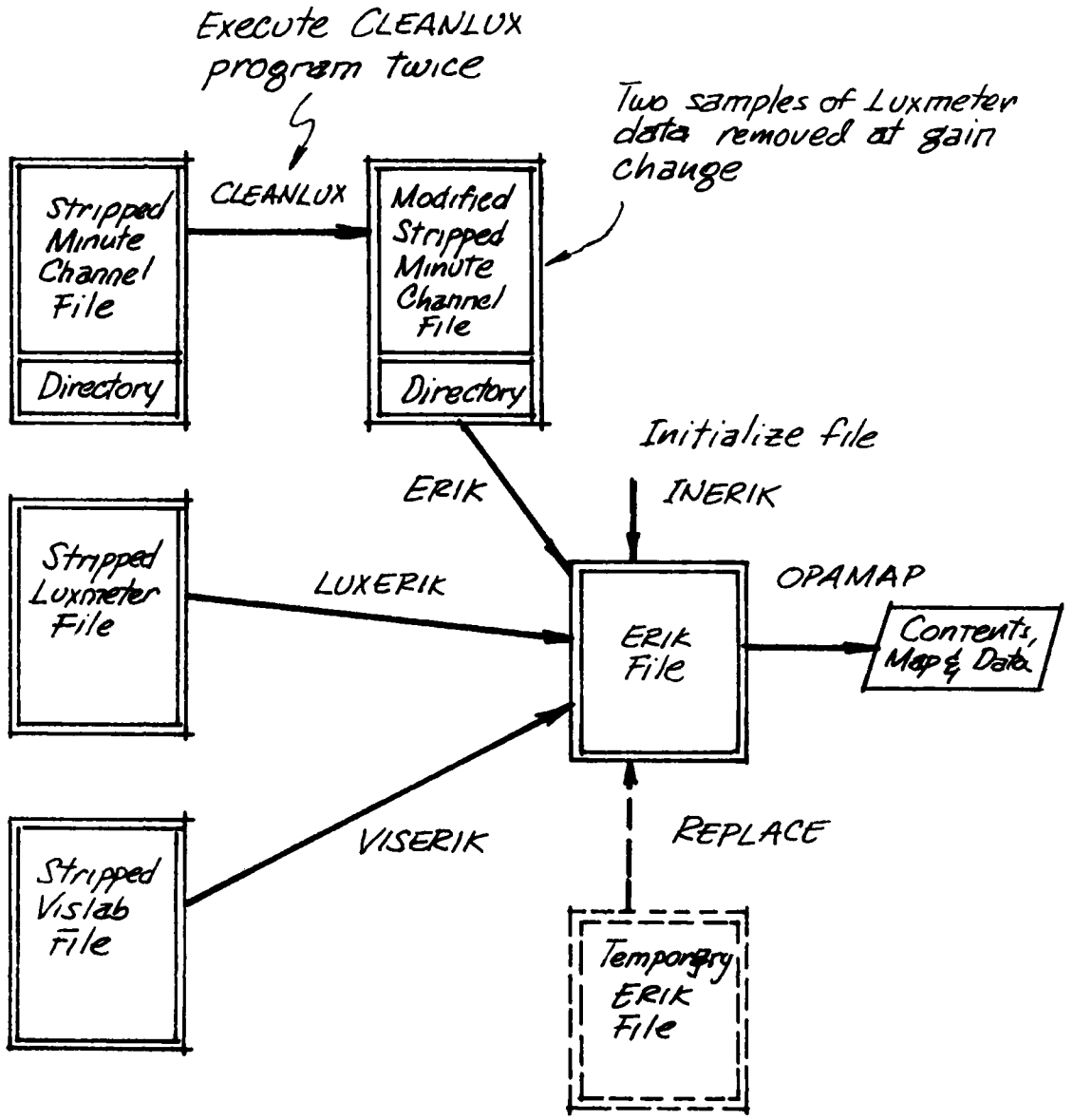


Figure 19. Overall View of ERIKFILE Generating Program

Stripped Vislab File. The three corresponding procedures used to accomplish this are ERIK, LUXERIK, and VISERIK. These procedures generally depend on the time periods of the data.

Before the ERIK file generation is done, it is necessary to modify the Stripped Minute Channel File with the procedure CLEANLX. The reason for doing this is briefly as follows. One of the instruments (the non-rotating luxmeter) has several ranges. When the ambient illumination reaches a certain level, the instrument range changes. This change has a time constant such that one or two of the stripped minute samples are invalid. The CLEANLX procedure searches the Stripped Minute Channel File and removes (makes the data look like it is missing) all samples where this change occurs. By executing this procedure twice, two consecutive samples where this range change occurs are removed. In Figure 19., the original and the modified Stripped Minute Channel files are in effect the same permanent file; a new Stripped Minute Channel File is not made in this modification procedure.

Sometimes it is desirable to change a few entries in the ERIK file while leaving the others intact. This can be accomplished with the REPLACE procedure. A Temporary ERIK File containing the required new values is generated exactly as the ERIK File. Values in this temporary file can then replace corresponding values in the ERIK File. In general, one or more channels (1 to 85) can be changed between any two times in the month.

The contents of the ERIK File can be examined with the OPAMAP procedure. Outputs that can be generated include daily maps (either for individual days or for a complete month) and numerical data in various forms.

II.9 ERIKFILE DATA TAPE DIRECTORY

The ERIKFILE data files that are produced by the software package described above are stored on magnetic tapes issued, catalogued, and housed at the A.F.G.L. Computer Center. Table 14., the Computer Center (CC) ERIKFILE Data Tape Directory, lists all of the active CC tapes by tape number and the data intervals represented.

Due to the time and effort required in generating these data tapes, and the possibilities for program or human error in processing the data contained on these tapes, a double or backup copy of each CC stripped data tape is generated and stored by the ULowell contractor. Table 15., tne Backup (OPA) ERIKFILE Data Tape Directory, lists all of the active backup tapes by tape number and the data intervals represented.

Table 14. Computer Center (CC) ERIKFILE Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977						1586	1586	1586	1586	1586	1586	1586
1978	1586	1586	1586	1586	1586	1586	1586	1586	1586	1586	1586	1586
1979	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801
1980	2801	2801	2801	2801	2801	2801	2801	2801				

Table 15. Backup (OPA) ERIKFILE Data Tape Directory

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977						700	700	700	700	700	700	700
1978	700	700	700	700	700	700	700	700	700	700	700	700
1979	702	702	702	702	702	702	702	702	702	702	702	702
1980	702	702	702	702	702	702	702	702				

II.10 TIME PLOT GENERATION

A procedure was generated to produce consecutive time plots for all of the instruments so that their performance could be easily studied and compared. A time scale of 1 day/page was used, and the channels were plotted on separate graphs as follows:

1. AEG and/or ELTRO
2. NIGHT PATH INSTRUMENT
3. VPFM (photometer and aximuth)
4. CO_2 LASER (gain, meter, angle, and PAR)
5. BARNES (4 channels)
6. ILLUMINOMETER (vertical, horizontal, and aximuth)
7. EPPLEY (filtered and direct)

Time plots have been generated for the last half of 1977 and all of 1978. Samples are shown in Figures 20 through 26.

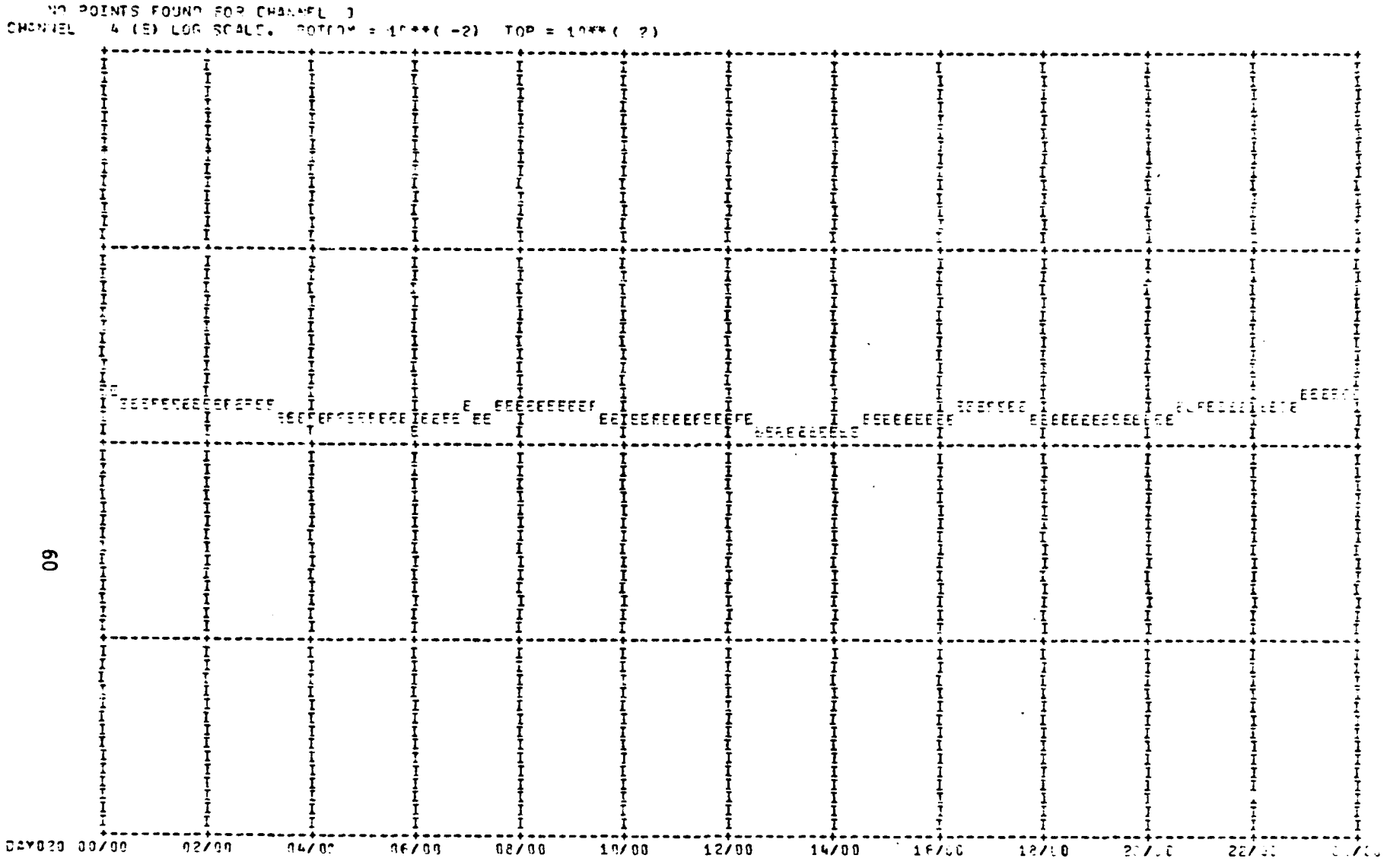


Figure 20. Time Plot: AEG or Fltro Transmissometer

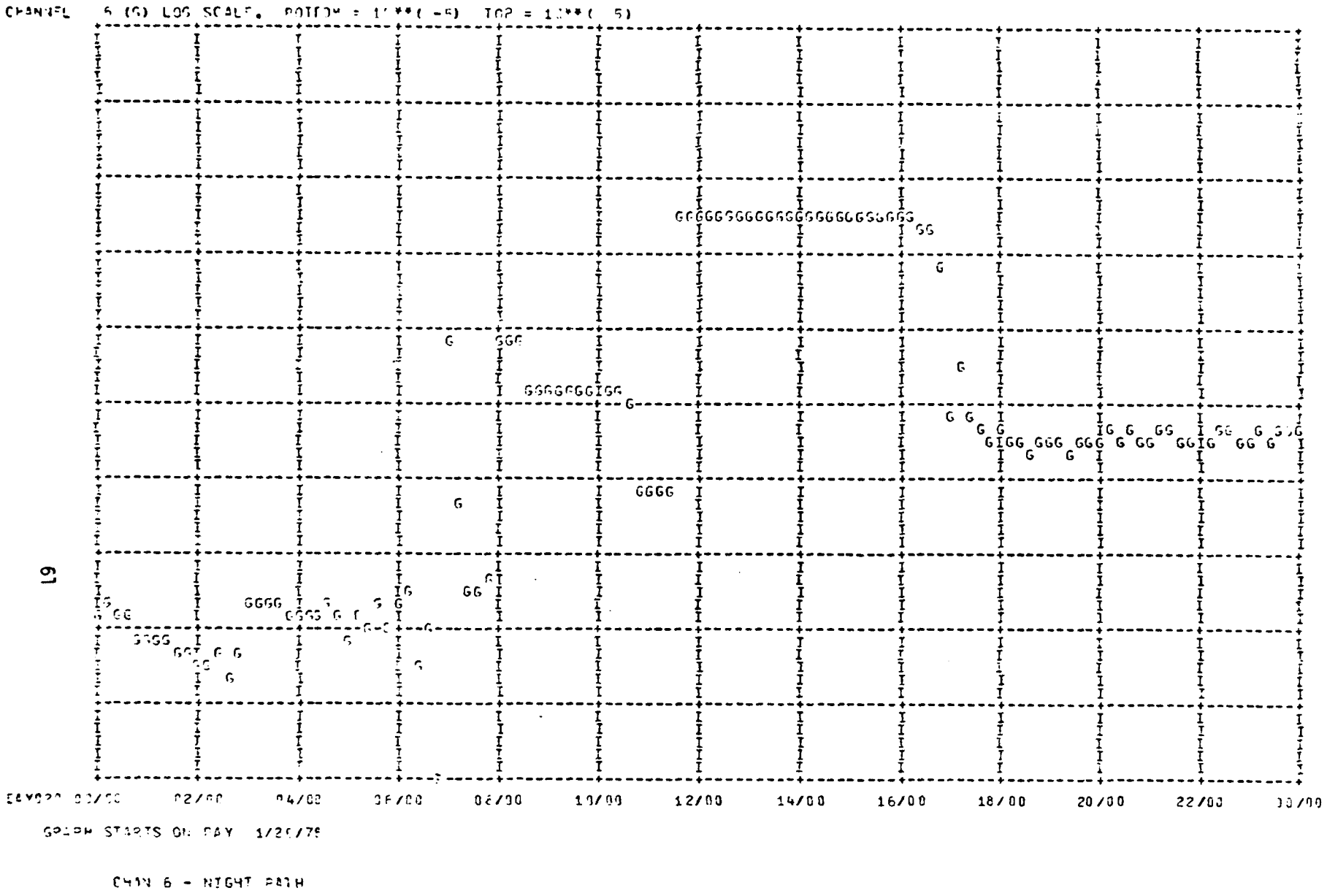


Figure 21. Time Plot: Night Path Luminance Meter

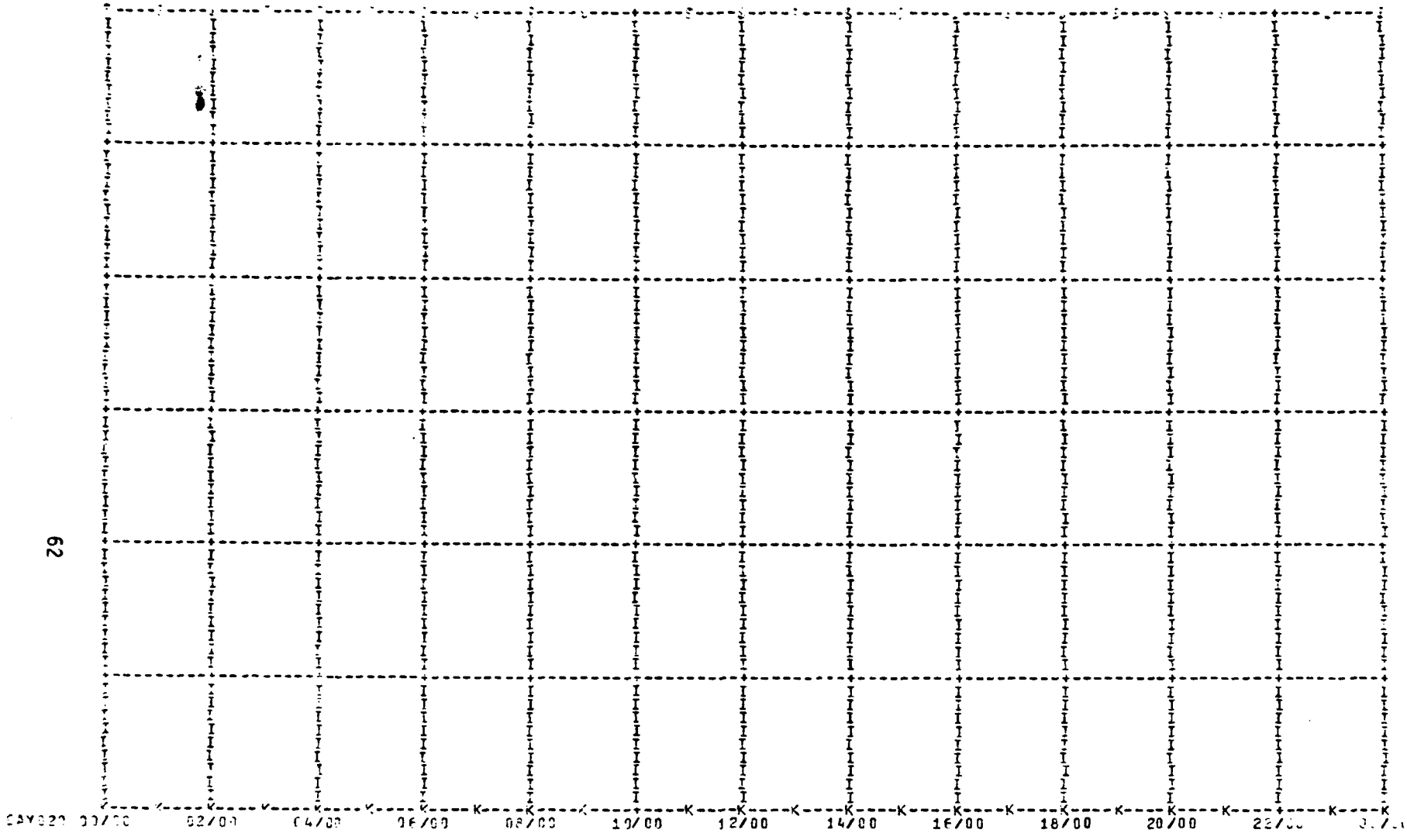
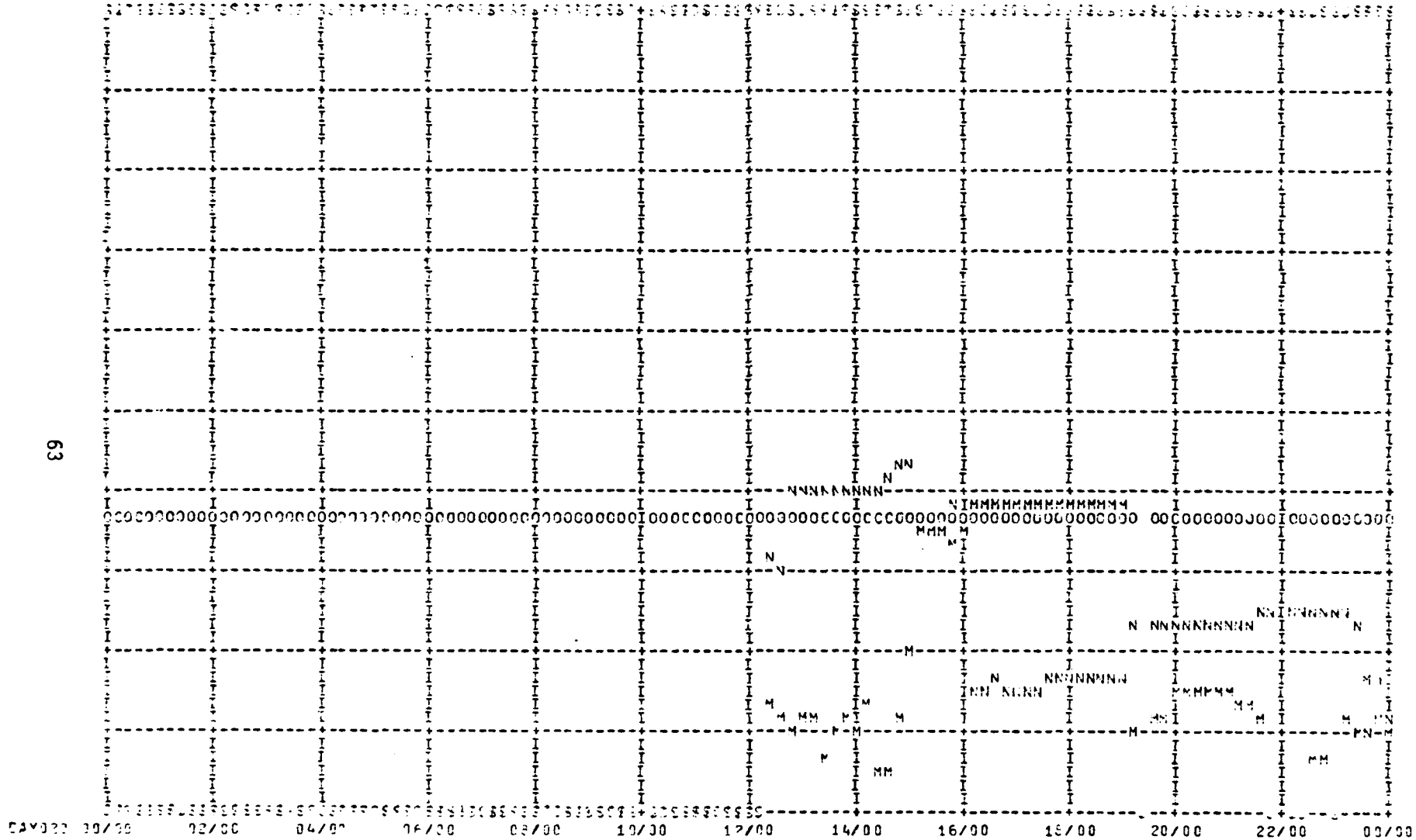


Figure 22. Time Plot: Variable Path Function Meter

ARRAY IS ZERO)
CHANNEL 17 (F) BOTTOM = 0. TOP = 1.00 EACH DIVISION = 1.000E-01
CHANNEL 15 (M) BOTTOM = 1. TOP = 3.00 EACH DIVISION = .300
ARRAY IS ZERO
CHANNEL 16 (C) BOTTOM = 0. TOP = 1.00 EACH DIVISION = 1.000E-01
CHANNEL 14 (M) LOG SCALE. BOTTOM = 1.**(-12) TOP = 10**(-2)



GRAPH STARTS ON DAY 1/00/79

CO2 LASER CHANS (17) GAIN, (15) METER, (16) ANGLE, (14) PAR.

Figure 23. Time Plot: CO2 Laser

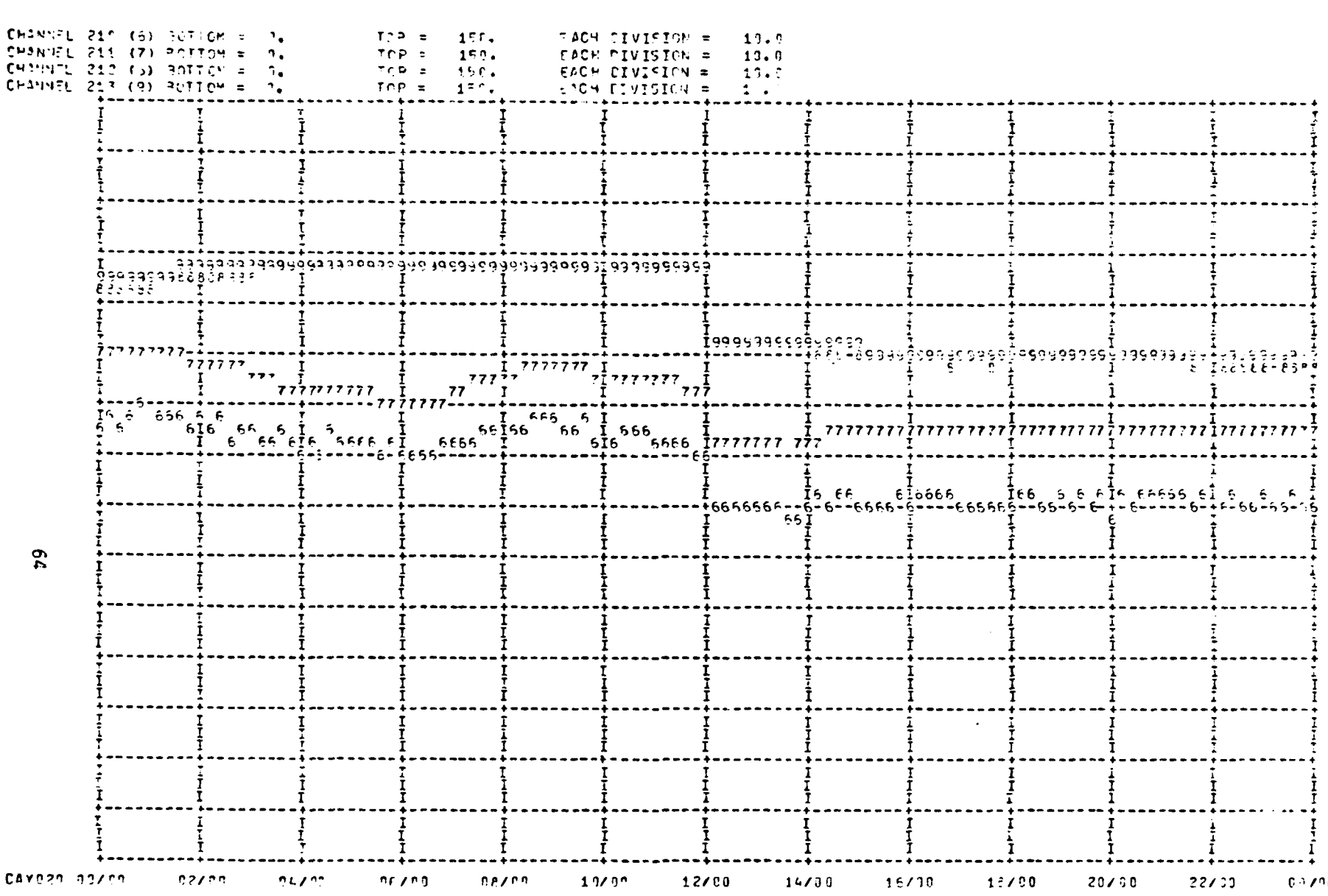


Figure 24. Time Plot: 500 Meter Barnes Transmissometer

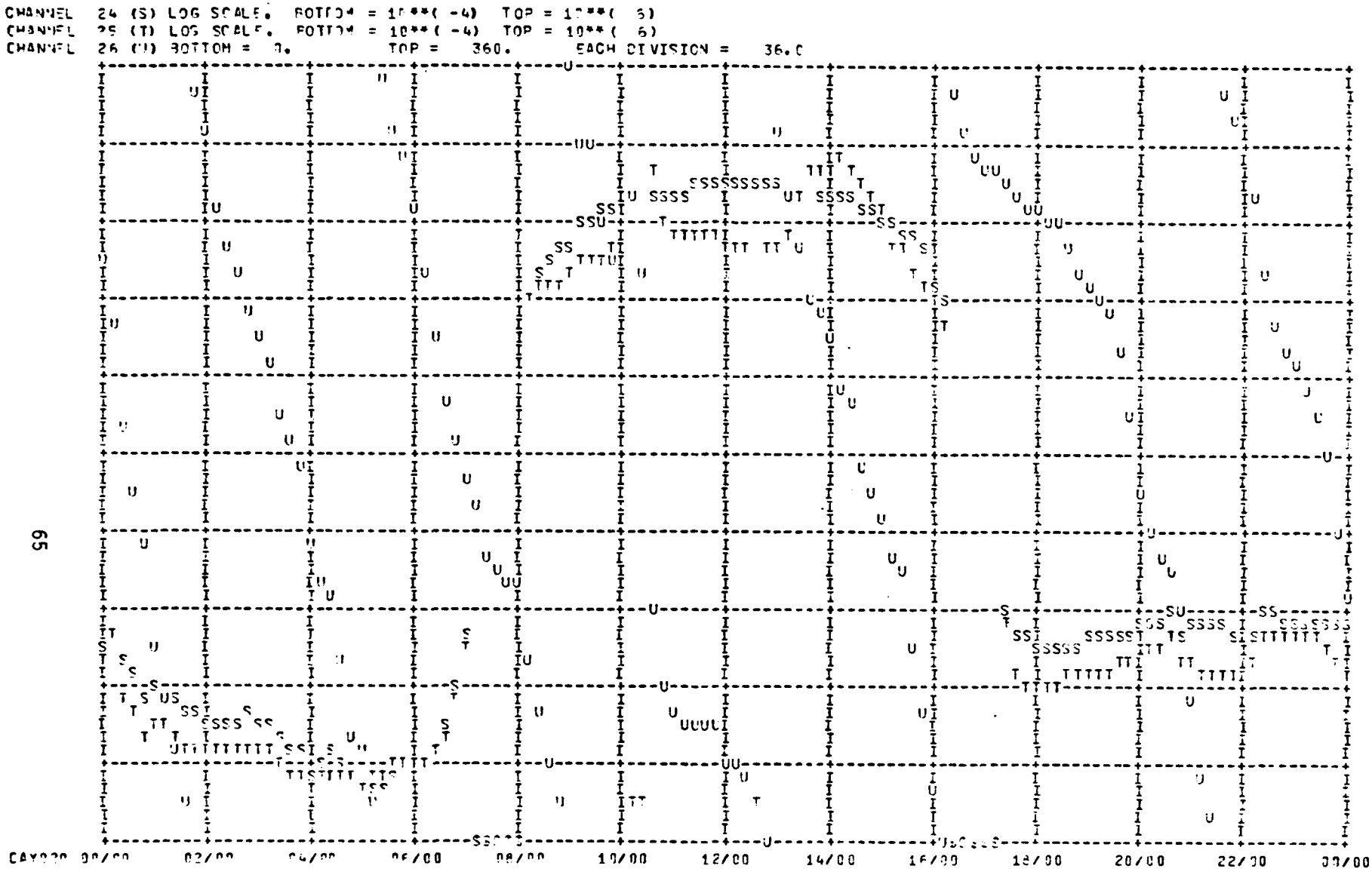


Figure 25. Time Plot: Illuminometer

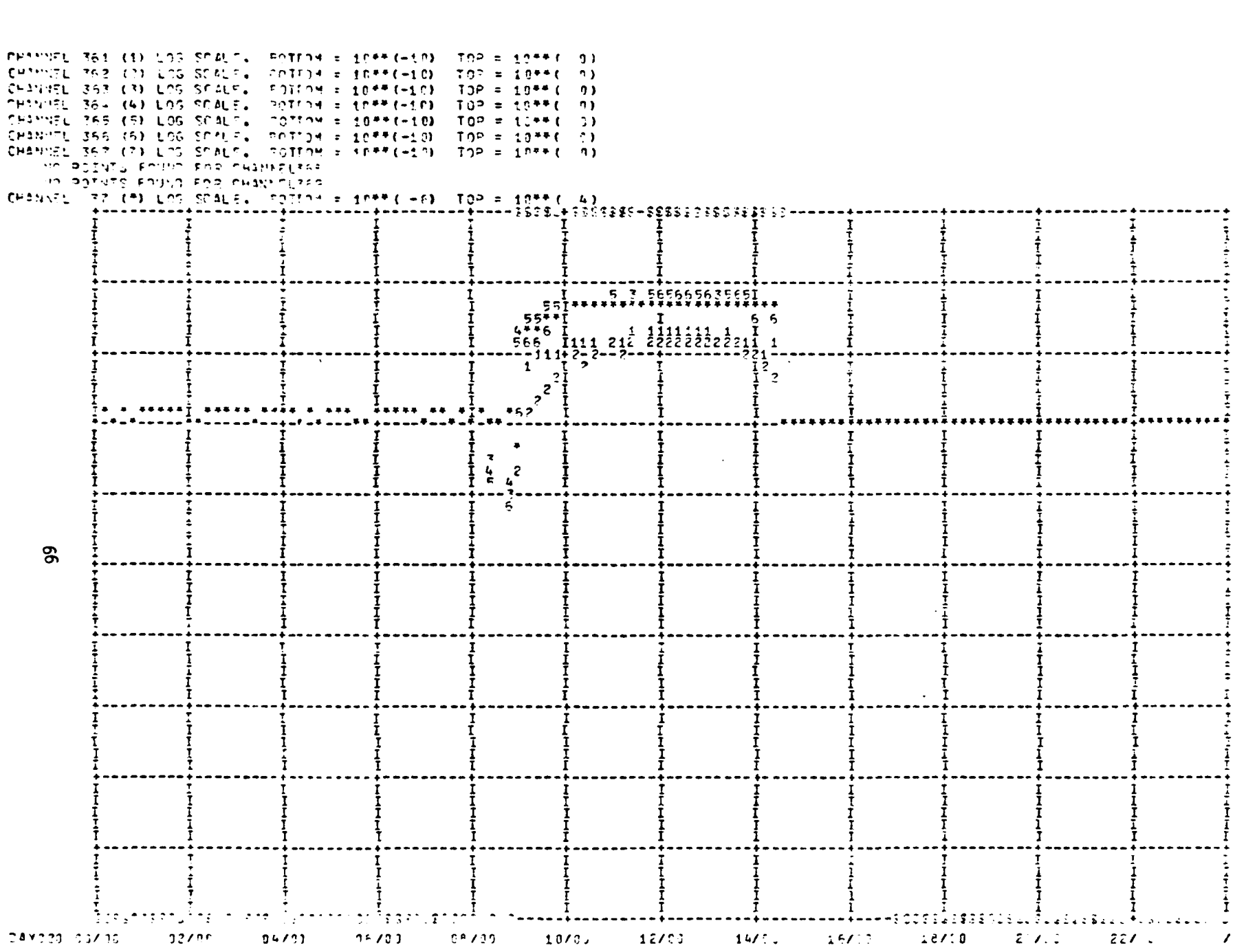


Figure 26. Time Plot: Pyroheliometer

APPENDIX A. OPAQUE DATA LOGGER CONTROL PROGRAMS

The design of the OPAQUE data logger/controller is based on the use of an Intel 8008 microprocessor with a memory-stored control structure to facilitate on-site changes to the experiment sampling rates and allows instruments to be added or deleted as desired. Since the initial installation in 1976, the mix of instruments and the data sampling rates have undergone numerous changes. The use of eight input ports and eight output ports for all I/O operations allows both internal processing operations and the ability to map any input bit to any output bit. The use of this technique can be seen throughout the program listing in Appendix B and lends the necessary flexibility to continuously update the data logger/controller.

Another feature that has been invaluable in the field modifications is the collection of utility programs that were designed along with the hardware which enable the data logger/controller to be used for the development and debugging of new subroutine or modifications to existing routines. These routines are described as they occur in the listing.

The listing is formatted as follows:

a) A Memory Map giving the memory locations for all the 'stand-alone' programs and the subroutines in terms of their absolute addresses (a few of these routines are relocatable).

b) A standardized description is given for each routine that includes a description of the routine and its intended use, the entry and exit locations for the routine, the CPU resistors used, any reserved locations used, the input/output ports used, other subroutines called by the routine being discussed, and any alternate entry location into the routine.

c) A heavily annotated source listing of each routine in the standard assembly language format of page and byte address, the machine code, the nmeumonic instruction, and the comment area. A careful reading of the description and the comments given for each routine allows one to reconstruct the algorithmic flowchart that was used to initially develop the routine. A simple reading of the comments allows a reasonably rapid understanding of the purpose and use of each routine.

It should be noted that all of these routines could be modified to operate on an 8080, 8085, or Z-80 microprocessor if the CPU resistor codes were changed, and a hardware stack established for subroutine calls and returns along with readdressing the I/O ports.

APPENDIX B. MEMORY MAP of OPAQUE DATA LOGGER/CONTROLLER PROGRAMS - Absolute Memory Locations

Routine Name	Start Addr. (ps-byte)	End Addr. (ps-byte)
RST's	00-000	00-067
MAIN	00-070	00-213
CHTEST	00-250	00-316
ADVT	00-317	00-334
CLOCK	01-000	01-115
CMD	01-116	01-132
PMT	01-133	01-155
DSPY	01-156	01-163
TIME	01-200	01-313
TPTFMT	01-320	01-370
TYMSYN	02-000	02-027
SCANSEC	02-030	02-047
STCK	02-070	02-123
BLKSZ	02-140	02-177
MRCDR	02-200	02-244
SHIFT	02-260	02-303
PACKER	02-320	02-377
DPTFMT	03-000	03-025
Reserved	03-100	03-377
DIGMUX	04-000	04-064
TWTFMT	04-100	04-137
DWTFMT	04-140	04-162
CLEAR	04-200	04-307
VERIFY	04-310	04-371
BINLD	05-000	05-035
RDY	05-036	05-047
ERRPRNT	05-050	05-077
PDUMP	05-100	05-135
PRDY	05-136	05-146
LDTR	05-147	05-163
PROGIN	05-200	05-251
ASTK	05-252	05-270
MDUMP	05-300	05-355
SPACE	05-356	05-372
PNTBIN	06-000	06-037
FORMAT	06-040	06-061
CRLF	06-100	06-122
TYMTAG	06-140	06-160
RDRCNTL	06-161	06-175
MIN	06-200	06-243
BLKCTR	06-250	06-267
INSTIN	06-300	06-355
PUSH A	06-360	06-365
POP A	06-366	06-374
LOADER	07-000	07-031
LDLINK	07-050	07-056
AEGSEC	07-100	07-124
AEGLOC	07-150	07-177
GLOOK	07-210	07-232
XFER	07-242	07-274
ADTEST	07-300	07-341
ENDE	07-342	07-373

OPAQUE Data Logger/Controller Programs
for 8008 microprocessor

The following eight RST (restart) instructions as for operator use in selecting any one of the eight major operational programs.

```
0    0    104      RST0,JMP  005  000 / Jump to BINLD, loads all
               000                     / eight pages of RAM
               005                     / from binary tape
0    3    000           HLT           / punched by PDUMP.
0    4    000           HLT
0    5    000           HLT
0    6    000           HLT
0    7    000           HLT
0    10   104      RST1,JMP  006  300 / Jump to INSTIN, allows
               300                     / entry of machine codes
               006                     / into memory at page(=H)
0    13   000           HLT           / and byte(=L). Loading
0    14   000           HLT           / continues to the end of
0    15   000           HLT           / selected page.
0    16   000           HLT
0    17   000           HLT
0    20   104      RST2,JMP  005  300 / Jump to MDUMP, prints
               300                     / on TTY the contents of
               005                     / the selected memory page
0    23   000           HLT           / starting at byte(=L).
0    24   000           HLT
0    25   104           JMP  005  200 / Jump to PROGIN, packs
               200                     / 3 ASCII digits into 3
               005                     / octal digits (not>377).
0    30   104      RST3,JMP  005  100 / Jump to PDUMP, punches
               100                     / memory pages 0 to 7 on
               005                     / paper tape in binary.
0    33   000           HLT           / Formatted for loading
0    34   000           HLT           / with program BINLD.
0    35   000           HLT
0    36   000           HLT
0    37   000           HLT
0    40   104      RST4,JMP  007  300 / Jump to ADTEST, displays
               300                     / the A/D conversion value
               007                     / for the analog channel
0    43   000           HLT           / selected by the console
0    44   000           HLT           / switches.
0    45   000           HLT           / Discrete bits can be
0    46   000           HLT           / displayed on panel LEDs.
0    47   000           HLT
0    50   104      RST5,JMP  007  210 / Jump to GLOOK, prints
               210                     / the last 256 bytes
               007                     / written to the magnetic
0    53   000           HLT           / tape and resumes auto
0    54   000           HLT           / sampling operations.
0    55   000           HLT
```

```
0   56      000             HLT
0   57      000             HLT
0   60      104         RST6,JMP   004  310 / Jump to VERIFY, used to
                                             / compare and correct
                                             / stored machine codes.
0   63      000             HLT              / The value stored at
0   64      000             HLT              / a given location is
0   65      000             HLT              / compared with the paper
0   66      000             HLT              / tape value and corrected
0   67      000             HLT              / to tape value if wrong.
```

Program MAIN.
Description: Main linking program which carries out the sequential sampling of all analog data channels, formats time and data words, and writes these to magnetic tape. Once initiated, runs automatically until terminated by end-of-tape condition, system malfunction, or operator intervention.
Entry point: 00-070
End of routine: 00-213
CPU Registers used: A,E,H,L
Reserved locations used: SCAN flag (03-220)
TIME TAG flag (03-221)
REQUEST Pointer (03-222)
Input/Output ports used: None
Subroutines called: CLEAR, CLOCK, TYMSYN, CHTEST, MIN, TWTFMT, DIGMUX, DWTFMT.
Alternate entry point: PROG at 00-073

```
0   70      106        MAIN,CAL   004  200 / Call CLEAR routine
                                             / (initializes all arrays
                                             / and counters)
0   73      106        PROG,CAL   001  000 / Call CLOCK routine
                                             / ( sets the current time
                                             / word via 488 interface)
0   76      106             CAL   002  000 / Call TYMSYN routine
                                             / (modifies time mask for
                                             / sampling scan nephl.)
0   101     304             LAE             / Get sampling time mask.
0   102     074             CPI   000       / Is mask =000?  If =0,
                                             / time change < 1 sec.
0   104     150             JTZ   000  073 / Jump to PROG if mask= 0
                                             / and update sampling time
                                             / mask.
0   107     074             CPI   001       / Is time mask =1?  Tests
                                             / for 1 sec-continuous bit
0   111     104             JMP   000  220 / Jump to TEST second mask
                                             / for both 1 sec. continuous
                                             / and 1 sec/10 min masks.
0   114     056        SAMPL,LHI   003       / Set memory byte pointer
                                             / to page 3, byte 221, the
0   116     066             LLI   221       / location of the TIME TAG
                                             / ON/OFF flag register.
0   120     076             LMI   077       / Load flag with 077 to
                                             / turn flag ON.
0   122     060             INL             / Increment byte pointer.
0   123     076             LMI   277       / Load(start address-1) of
                                             / sampling REQUEST array.
```

```
0  125     106        CYCLE,CAL   000   250 / Call CHTEST routine
           250                               / (compares time mask with
           000                               / REQUEST array elements)
0  130     056              LHI   003       / Set memory byte pointer
           003                               / to page 3, byte 220, the
0  132     066              LLI   220       / scan analog channels
           220                               / flag set by CHTEST as
0  134     307              LAM             / 0=stop, 1=sample.
0  135     074              CPI   000       / Test sampling request
           000                               / bit.
0  137     150              JTZ   000   145 / Jump to PASS if no
           145                               / sampling is requested,
           000                               / i.e., SCAN flag is zero.
0  142     104              JMP   000   153 / Jump to CONT if channel
           153                               / sampling is requested.
           000
0  145     106         PASS,CAL   006   200 / Call MIN routine
           200                               / (outputs one minute
           006                               / experiment commands)
0  150     104              JMP   000   073 / Jump to PROG, all chan-
           073                               / requesting service this
           000                               / scan have been sampled.
0  153     066         CONT,LLI   221       / Get TIME TAG flag at
           221                               / page 3, byte 221.
0  155     307              LAM             / If flag =77, write time
0  156     074              CPI   077       / word as the first word
           077                               / of new sampling scan.
0  160     150              JTZ   000   166 / Jump to STAMP if flag
           166                               / is set (=77).
           000
0  163     104              JMP   000   205 / Jump to VALUE and write
           205                               / a data word to tape.
           000
0  166     106        STAMP,CAL   004   100 / Call TWTFMT routine
           100                               / (formats and writes time
           004                               / words of 12 hex digits)
0  171     106        PASSN,CAL   004   000 / Call DIGMUX routine
           000                               / (loads SHIFT array with
           004                               / 9 hex digit data word)
0  174     300              LAA / "hooks for additional calls"
0  175     300              LAA
0  176     300              LAA
0  177     300              LAA
0  200     300              LAA
0  201     300              LAA / "hooks for additional calls"
0  202     104              JMP   000   125 / Jump to CYCLE and
           125                               / continue channel
           000                               / REQUEST testing.
0  205     106        VALUE,CAL   004   140 / Call DWTFMT routine
           140                               / (formats and writes
           004                               / 9 hex digit data word)
0  210     104              JMP   000   171 / Jump to PASSN to exit
           171                               / from scanning for data
           000                               / channel sample requests.
0  213     000              HLT             / end of MAIN
0  214     000
0  215     000
0  216     000
0  217     000
```

```
0  220     074       TEST,CPI  005       / Test for 1 sec/continuous
0          005                           / and 1 sec/10 minute masks.
0  222     150            JTZ  000 073   / Jump to PROG if mask = 5
0          073                           / and update sampling time
0          000                           / mask.
0  225     074            CPI  001       / Test for 1 sec/continuous.
0          001                           /
0  227     150            JTZ  000 073   / Jump to PROG and continue.
0          073                           /
0          000                           /
0  232     104            JMP  000 114   / Jump to SAMPL, time mask not
0          114                           / 1 sec/continuous or 1 sec/min.
0          000                           /
0  235     000            HLT            /
```

Subroutine CHTEST.
Description: Compares time word mask in register E with each of the analog channel sample request masks in the REQUEST array. When a match occurs, the last two digits of the array byte address are converted to Binary-Coded-Decimal, BCD, and stored in the ANALOG ADDRESS Latch register and the A/D conversion is initiated on the selected analog channel.
Entry point: 00-250
End of routine: 00-316
CPU Registers used: A,D,E,H,L
Reserved locations used: SCAN flag (03-320)
REQUEST array pointer (03-222)
REQUEST array (from 03-300 to 03-340)
Input/Output ports used: OUT+26, ANALOG ADDRESS Latch Register
Subroutines called: ADVT
Alternate entry point: LINK at 00-270

```
0  250     056     CHTEST,LHI  003       / Set memory byte pointer
           003                           / to page 3, byte 222 and
0  252     066           LLI  222       / set REQUEST array
           222                           / pointer.
0  254     367           LLM            / Increment REQUEST array
0  255     060       NEXT,INL           / pointer.
0  256     307           LAM            / Get next REQUEST mask.
0  257     074           CPI  000       / If mask= 000, scan at
           000                           / end of REQUEST array.
0  261     150           JTZ  000  313  / Jump to SCAN if mask
           313                           / contains 000.
           000
0  264     244           NDE            / Test for 1 bit match.
0  265     150           JTZ  000  255  / Jump to NEXT if no bits
           255                           / match and set the next
           000                           / REQUEST mask.
0  270     306       LINK,LAL           / 1 or more bits match.
0  271     044           NDI  007       / Mask REQUEST array byte
           007                           / pointer for low 3 bits.
0  273     330           LDA            / Store in D.
0  274     306           LAL            / Get byte pointer again.
0  275     022           RAL            / Shift left, octal to BCD
0  276     044           NDI  160       / Mask for middle 3 bits.
           160
0  300     263           ORD            / OR with D to form BCD.
```

```
0  301     127            OUT+26       / Output Analog Addr in BCD
0  302     106            CAL  000  317 / Call ADVT routine
           317                         / (initiates A/D convert
           000                         / on addressed channel)
0  305     336            LDL          / Store REQUEST array
0  306     066            LLI  222     / pointer back on page 3,
           222                         / byte 222.
0  310     373            LMD          / Do it.
0  311     006            LAI  001     / Set data channel service
           001                         / flag =1 on page 3, byte
0  313     066       SCAN,LLI  220     / 220 to keep analog
           220                         / sample REQUEST testing
0  315     370            LMA          / on for until channel 40.
0  316     007            RET          / end of CHTEST routine.
```

Subroutine ADVT.
Description: Tests for A/D converter BUSY, and when idle, initiates a conversion on the channel addressed by the ANALOG ADDRESS latch.
Entry point: 00-317
End of routine: 00-334
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: OUT+22, COMMAND Latch Register
INP+4, STATUS Latch Register
Subroutines called: None
Alternate entry point: None

```
0  317     105       ADVT,INP+4        / Input A/D status bit
0  320     044            NDI  040     / Mask with 00100000
           040                         / Test for A/D BUSY.
0  322     150            JTZ  000  317 / Jump to ADVT if A/D
           317                         / is BUSY.
           000
0  325     006            LAI  020     / Load A with 00010000
           020                         / Sets A/D convert bit.
0  327     123            OUT+22       / Output to COMMAND latch.
0  330     006            LAI  000     / Load A with 00000000
           000                         / Resets A/D convert bit.
0  332     123            OUT+22       / Output to COMMAND latch
0  333     007            RET          / end of ADVT routine.
0  334     000            HLT
```

Subroutine CLOCK.
Description: Controls the transfer of the day/time word from the digital clock to the TIME array by addressing the data logger as a "listener" and the clock as a "talker" on the 488 interface buss. Both the 488 CONTROL buss handshake sequence and the 488 DATA buss loading and unloading are carried out under this software control program. All data is in ASCII.
Entry point: 01-000
End of routine: 01-115
CPU Registers used: A,B,H,L
Reserved locations used: TIME array (from 03-200 to 03-217)
Input/Output ports used: INP+12, 488 CONTROL Buss

INP+16, 488 DATA Buss
OUT+32, 488 CONTROL Buss
OUT+36, 488 DATA Buss

Subroutines called: CMD, CMD1, CMD2, DSPY, TIME
Alternate entry point: None

```
1   0   006      CLOCK,LAI  000      / IEEE 488 Interface Buss
            000                      / program, digital clock.
1   2   137           OUT+36         / Clear DATA buss
1   3   006           LAI  040       / Load EOP command
            040                      / to clear interface.
1   5   106           CAL  001  120  / Call CMD1 routine
            120                      / (sends command to the
            001                      / CONTROL buss)
1   10  006           LAI  010       / Load listener address of
            010                      / the data logger.
1   12  137           OUT+36         / Send listen address
1   13  106           CAL  001  116  / Call CMD routine
            116                      / (initiates CONTROL buss
            001                      / handshake sequence)
1   16  006           LAI  321       / Load talker address of
            321                      / the digital clock.
1   20  137           OUT+36         / Send talk address
1   21  106           CAL  001  116  / Call CMD routine
            116
            001
1   24  006           LAI  000       / Set all DATA buss lines
            000                      / to zero.
1   26  137           OUT+36         / Send DATA buss clear
1   27  056           LHI  003       / Set memory byte pointer
            003                      / for page 3, byte 177.
1   31  066           LLI  177       / TIME array (start-1)
            177                      / address.
1   33  016           LBI  014       / Set number of ASCII time
            014                      / bytes.
1   35  060        OV,INL            / Point to 1st TIME byte.
1   36  006           LAI  034       / Load REN-NRFD-NDAC
            034                      / command.
1   40  133           OUT+32         / Send to 488 CONTROL buss
1   41  106           CAL  001  156  / Call DSPY routine.
            156                      / (used as software
            001                      / timing loop, p/o test)
1   44  006           LAI  024       / Load REN-NDAC command.
            024
1   46  133           OUT+32         / Send to 488 CONTROL buss
1   47  113        AG4,INP+12        / Input 488 CONTROL BUSS
1   50  074           CPI  025       / Compare REN-NDAC-DAV
            025                      / with 00010101.
1   52  110           JFZ  001  047  / Jump to AG4 until the
            047                      / clock places an ASCII
            001                      / time character on buss.
1   55  106           CAL  001  156  / Call DSPY routine.
            156                      / (software pause)
            001
1   60  117           INP+16         / Input DATA buss, ASCII.
1   61  106           CAL  001  200  / Call TIME routine to
            200                      / sample time mask in
            001                      / register E.
1   64  006           LAI  030       / Load REN-NRFD command
```

```
            030                         / to signal data received
1   66      133         OUT+32          / Send to 488 CONTROL buss
1   67      106         CAL  001  156   / Call DSPY routine.
            156                         / (software wait loop)
            001
1   72      011         DCB             / Decrement # byte counter
1   73      110         JFZ  001  035   / Jump to 0V until all
            035                         / time bytes have been
            001                         / received by data logger.
1   76      106         CAL  001  124   / Call CMD2 routine to
            124                         / restore 488 busses to
            001                         / remote/idle state.
1  101      006         LAI  137        / Load untalk command for
            137                         / digital clock.
1  103      137         OUT+36          / Send to 488 DATA buss
1  104      106         CAL  001  116   / Call CMD routine to
            116                         / carry out handshake
            001                         / sequence.
1  107      106         CAL  001  133   / Call PMT routine.
            133                         / (echo prints contents
            001                         / of TIME array for test)
1  112      006         LAI  000        / Load 488 DATA buss clear
            000                         / command.
1  114      137         OUT+36          / Send to 488 DATA buss
1  115      007         RET             / end of CLOCK routine
```

Subroutine CMD.
Description: Loads 488 CONTROL buss with REN-MRE-DAV commands.
Entry point: 01-116
End of routine: 01-132
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: OUT+32, 488 CONTROL Buss
Subroutines called: DSPY
Alternate entry points: CMD1 at 01-120, CMD2 at 01-124

```
1  116      006       CMD,LAI  023      / Load REN-MRE-DAV
            023                         / command.
1  120      133      CMD1,OUT+32        / Send to 488 CONTROL buss
1  121      106           CAL  001  156 / Call DSPY routine.
            156                         / (software pause loop)
            001
1  124      006      CMD2,LAI  020      / Load REN command.
            020
1  126      133           OUT+32        / Send to 488 CONTROL buss
1  127      106           CAL  001  156 / Call DSPY routine.
            156                         / (software wait loop)
            001
1  132      007           RET           / end of CMD routine
```

Subroutine PMT.
Description: Prints the day/time word stored in the array TIME.
No conversion is needed as all bytes on the 488
DATA buss are transmitted and received in ASCII.
First instruction, RET (007), must be replaced by
LLI (066) to enable print-out. Used for testing.
Entry point: 01-133

```
End of routine: 01-155
CPU Registers used: A,B,L
Reserved locations used: TIME array (from 03-200 to 03-215)
Input/Output ports used: INP+2, TTY Status
                         OUT+20, OUTPUT to TTY
Subroutines called: None
Alternate entry point: PRNT at 01-137

1  133     007        PMT,RET            / Change to LLI(=066) to
1  134     177                           / echo print TIME array.
1  135     016            LBI  020       / Set B= number of ASCII
           020                           / TIME bytes for print.
1  137     300       PRNT,LAA            / Move A to A ( a NOP)
1  140     060         LO,INL            / Point to next TIME byte
1  141     103         GO,INP+2          / Input TTY status latch
1  142     032            RAR            / Shift A right one bit
1  143     032            RAR
1  144     100            JFC  001  141  / Jump to GO if the TTY
           141                           / is busy.
           001
1  147     307            LAM            / Get ASCII character.
1  150     121            OUT+20         / Output to TTY for print.
1  151     011            DCB            / Decrement # byte counter
1  152     110            JFZ  001  140  / Jump to LO until all
           140                           / TIME bytes are printed.
           001
1  155     007            RET            / end of PMT routine


Subroutine DSPY.
Description: Uses DATA Latch to display 488 CONTROL Buss contents,
             and DIGMUX Latch to display 488 DATA Buss contents
             on front panel LED's.  Routine time of execution used
             as a software timing loop for CLOCK routine.
Entry point: 01-156
End of routine: 01-163
CPU Register used: A
Reserved locations used: None
Input/Output ports used: INP+12, 488 CONTROL Buss Input
                         INP+16, 488 DATA Buss Input
                         OUT+24, 488 DATA Latch
                         OUT+30, DIGMUX Latch
Subroutines called: None
Alternate entry points: None

1  156     113       DSPY,INP+12         / Input 488 CONTROL buss.
1  157     125            OUT+24         / Output to DATA latch.
1  160     117            INP+16         / Input 488 DATA buss.
1  161     131            OUT+30         / Output to DIGMUX latch.
1  162     007            RET            / end of DSPY routine
1  163     000            HLT


Subroutine TIME.
Description: Called by CLOCK routine after each ASCII time byte
             is read in from the digital clock to generate the
             the sample time mask in register E.  The time mask
             is generated in bit positions 0,1,2,3, with bits
             4 and 5 modified by TYMSYN and LUXSEC.
```

```
Entry point: 01-200
End of routine: 01-313
CPU Registers used: A,D,E,L

Reserved locations used: TIME array (from 03-200 to 03-215)
Input/Output ports used: None
Subroutines called: None
Alternate entry points: None

1  200   330      TIME,LDA          / Save time byte in reg D.
1  201   306           LAL          / Get time array pointer.
1  202   074           CPI  207     / Pointing at 10s of
         207                        / minutes byte?
1  204   140           JTC  001 307 / Jump to EX if pointing
         307                        / at byte before 10s of
         001                        / minutes.
1  207   150           JTZ  001 272 / Jump to EX1 if pointing
         272                        / at 10s of minutes byte.
         001
1  212   074           CPI  210     / Pointing at unit
         210                        / minutes byte?
1  214   150           JTZ  001 240 / Jump to EX3 if pointing
         240                        / at unit minutes byte.
         001
1  217   074           CPI  212     / Pointing at unit
         212                        / seconds byte?
1  221   110           JFZ  001 307 / Jump to EX if not
         307                        / pointing at unit
         001                        / seconds byte.
1  224   303           LAD          / Move saved byte to A.
1  225   277           CPM          / Compare old vs new byte.
1  226   150           JTZ  001 263 / Jump to EX5 if time
         263                        / byte has not changed.
         001
1  231   304           LAE          / Get sample time mask, E.
1  232   044           NDI  017     / Mask with 00001111
         017                        / Sets lower byte to 1111.
1  234   340           LEA          / Store mask back in E.
1  235   104           JMP  001 307 /  Jump to EX
         307
         001
1  240   303      EX3,LAD           / Get byte saved in reg D.
1  241   277           CPM          / Compare old vs new byte.
1  242   150           JTZ  001 254 / Jump to EX4 if the unit
         254                        / minutes byte has not
         001                        / changed.
1  245   304           LAE          / Get time mask from E.
1  246   044           NDI  017     / Mask with 00001111
         017                        / Reset high byte =0000.
1  250   340           LEA          / Save time mask in reg E.
1  251   104           JMP  001 307 / Jump to EX
         307
         001
1  254   304      EX4,LAE           / Get time mask from E.
1  255   044           NDI  005     / Mask with 00000101
         005                        / Resets 1 minute samples.
1  257   340           LEA          / Save time mask in reg E.
1  260   104           JMP  001 307 / Jump to EX
         307
         001
```

```
1  263     304        EX5,LAE            / Get time mask from E.
1  264     044            NDI  000       / Mask with 00000000
           000                           / Reset all time mask bits
1  266     340            LEA            / Save time mask in reg E.
1  267     104            JMP  001  307  / Jump to EX
           307
           001
1  272     303        EX1,LAD            / Get saved byte from D.
1  273     074            CPI  060       / Does 10s of minutes
           060                           / byte= 0?
1  275     150            JTZ  001  305  / Jump to EX2 if 10s of
           305                           / minutes byte is zero.
           001
1  300     046            LEI  003       / Sets 1 minute-continuous
           003                           / bit in time mask.
1  302     104            JMP  001  307  / Jump to EX
           307
           001
1  305     046        EX2,LEI  017       / Set time mask=00001111.
           017
1  307     373         EX,LMD            / Get saved byte in reg D.
1  310     304            LAE            / Move time mask to reg A.
1  311     125            OUT+24         / Output to DATA latch
1  312     007            RET            / end of TIME routine
1  313     000            HLT
```

Subroutine TPTFMT.
Description: Prints the contents of the TIME array directly on the TTY. Also contains links for writing contents to magnetic tape. Part of an earlier routine for recording in HEX format, but modified and retained for system testing.
Entry point: 01-320
End of routine: 01-370
CPU Registers used: A,B,C,H,L
Reserved locations used: TIME array (from 03-200 to 03-215)
SHIFT array (from 03-360 to 03-366)
Input/Output ports used: OUT+20, OUTPUT to TTY
Subroutines called: PACKER, CRLF, SHIFT, PRDY
Alternate entry point: TPT at 01-332

```
1  320     106     TPTFMT,CAL  002  320 / Call PACKER routine to
           320                         / load SHIFT array with
           002                         / TIME array bytes.
1  323     106          CAL    006  100 / Call CRLF routine
           100                         / (outputs a carriage
           006                         / return and line feed)
1  326     056          LHI    003     / Set page= 003
           003
1  330     026          LCI    014     / Set C=014, the number
           014                         / of print characters
1  332     016       TPT,LBI   004     / Set B=004, the number
           004                         / of bits shifted by SHIFT
1  334     106          CAL    002  260 / Call SHIFT routine
           260                         / (shifts hex digit into
           002                         / SHIFT array byte 360)
1  337     066          LLI    360     / Set memory byte pointer
           360                         / to 360.
```

```
1  341     307          LAM              / Move memory byte to A.
1  342     044          NDI  017         / Mask with 00001111
           017                           / for lower byte.
1  344     064          ORI  260         / OR with 10110000 to
           260                           / convert HEX to ASCII.
1  346     370          LMA              / Store ASCII in byte 360.
1  347     106          CAL  005  136    / Call PRDY routine
           136                           / (tests if TTY busy and
           005                           / returns only when idle)
1  352     307          LAM              / Get ASCII byte at 360.
1  353     121          OUT+20           / Output to TTY printer.
1  354     300          LAA              / Move A to A (=NOP)
1  355     300          LAA              / Idle
1  356     300          LAA              / Idle
1  357     021          DCC              / Decrement C
1  360     110          JFZ  001  332    / Jump to TPT if more
           332                           / bytes must be printed.
           001
1  363     066          LLI  221         / Set TIME TAG flag at
           221                           / page 3, byte 221= 0.
1  365     076          LMI  000
           000
1  367     007          RET              / end of TPTFMT routine
1  370     000          HLT
```

Subroutine TYMSYN.
Description. Controls setting and resetting of bit 4 in the time word sample mask for one second sampling for 1/2 hour on odd hours.
Entry point: 02-000
End of routine: 02-027
CPU Registers used: A,E,H,L
Reserved locations used: TIME array (03-207 to 03-215)
Input/Output ports used: None
Subroutines called: LUXLOC, SCANSEC
Alternate entry points: None

```
2   0      304    TYMSYN,LAE            / Move E(=time mask) to A
2   1      074          CPI  000         / Test for all bits zero.
           000
2   3      150          JTZ  002  026    / Jump to OUT if all bits
           026                           / in sample time mask
           002                           / are zero.
2   6      056          LHI  003         / Set memory byte pointer
           003                           / to page 03, byte 207
2   10     066          LLI  207         / Contains the 10s of
           207                           / minutes ASCII digit.
2   12     307          LAM              / Get 10s minute digit.
2   13     074          CPI  063         / Does A=063?  Test for
           063                           / minutes = or > 30.
2   15     100          JFC  002  023    / Jump to LUXLOC if 10s
           023                           / of minute digit is
           002                           / NOT less than 3.
2   20     106          CAL  002  030    / Call SCANSEC routine
           030                           / (tests for odd or even
           002                           / hour)
2   23     106    LUXLOC,CAL  007  150    / Call LUXLOC routine
```

```
                150                             / (resets SEConds counter
                007                             / at minute time change)
2    26         007          OUT,RET             / end of TYMSYN routine
2    27         000               HLT
```

Subroutine SCANSEC.
Description. Tests for even or odd hour. If even, do not set bit 4. If odd, set bit 4 for one second sampling over first half hour.
Note. LOC 30 = 066 for SCANSEC ON, LOC 30 = 007 for SCANSEC OFF.
Entry point: 02-030
End of routine: 02-047
CPU Registers used: A,E,H,L
Reserved locations used: TIME array (from 03-200 to 03-215)
Input/Output ports used: None
Subroutine called: None
Alternate entry points: None

```
2    30         066     SCANSEC,LLI  206        / Set memory byte pointer
                206                             / to byte 206 on page 3.
2    32         307             LAM             / Get unit hours digit.
2    33         044             NDI  001        / Mask with 00000001
                001                             / (tests LSB = 1?)
2    35         074             CPI  000        / Does A=0? ( 1= odd hour
                000                             / 0= even hour)
2    37         150             JTZ  002  046   / Jump to BACK if on an
                046                             / even hour.
                002
2    42         304             LAE             / Move E(=time mask) to A
2    43         064             ORI  020        / OR with 00010000 to set
                020                             / the 1 sec/30 min bit.
2    45         340             LEA             / Store mask back in E
2    46         007        BACK,RET             / end of SCANSEC routine
2    47         000             HLT
```

Subroutine STCK.
Description. Tests for status of the magnetic tape recorder. If recorder is not READY, or at EOT (end-of-tape), issues a program/system HALT. If the recorder is BUSY writing data or in a GAP operation, program waits until not BUSY or not GAP before returning to calling routine. Also includes a software timing delay loop of 48 microseconds for the tape write operation.
Entry point: 02-070
End of routine: 02-123
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: INP+4, RECORDER and A/D STATUS
Subroutines called: None
Alternate entry points: None

```
2    70         105        STCK,INP+4           / Input recorder status
2    71         044             NDI  001        / Mask with 00000001
                001                             /  READY status =001
2    73         110             JFZ  002  123   / Jump to STOP if the
                123                             / recorder is not READY.
```

```
                002                                 / (STOPs the data logger)
2    76         105          RD1,INP+4             / Input recorder status
2    77         044              NDI  006          / Mask with 00000110
                006                                 /  BUSY=002, GAP=004
2   101         110              JFZ  002  076     / Jump to RD1 if the
                076                                 / recorder is BUSY or
                002                                 / in a GAP operation.
2   104         105              INP+4             / Input recorder status
2   105         044              NDI  010          / Mask with 00001000
                010                                 /  EOT status= 010
2   107         110              JFZ  002  123     / Jump to STOP if the
                123                                 / recorder is at the End-
                002                                 / Of-Tape (EOT) marker.
2   112         006              LAI  014          / Set A=014 (initial
                014                                 / counter value)
2   114         300              LAA               / Idle
2   115         024           OV,SUI  001          / Subtract 1 from A
                001
2   117         110              JFZ  002  114     / Jump to OV if counter >0
                114                                 / (software timing loop
                002                                 / for rcdr. BUSY signal)
2   122         007              RET               / end of STCK routine
2   123         000              HLT
```

Subroutine BLKSZ.
Description. Fixes tape block size to 2040 six-bit characters.
Assumes location 03-370 preloaded with 10, and
location 03-371 preloaded with 376 by CLEAR routine.
Entry point: 02-140
End of routine: 02-177
CPU Registers used: A,B,H,L
Reserved locations used: Upper byte of BLKSZ counter (03-370)
Lower byte of BLKSZ counter (03-371)
Input/Output ports used: OUT+22, COMMAND Latch Register
Subroutines called: BLKCTR
Alternate entry points: None

```
2   140         056        BLKSZ,LHI  003          / Set memory byte pointer
                003                                 / to page 3, byte 371.
2   142         066              LLI  371          / Contains low byte of #
                371                                 / characters counter.
2   144         317              LBM               / Get memory byte in B
2   145         011              DCB               / Decrement B
2   146         371              LMB               / Move B back to Memory
2   147         110              JFZ  002  177     / Jump to BLK if byte
                177                                 / value > 0.
                002
2   152         076              LMI  376          / Reset low byte of #
                376                                 / char. counter to 376)
2   154         066              LLI  370          / Set memory byte pointer
                370                                 / to byte 370 on page 3.
2   156         317              LBM               / Get byte value in B.
2   157         011              DCB               / Decrement B
2   160         371              LMB               / Move B back to Memory
2   161         110              JFZ  002  177     / Jump to BLK if high byte
                177                                 / of # character counter
                002                                 / is not zero.
2   164         076              LMI  010          / Reset high byte to 010
```

```
                010
2  166          106             CAL  006  250 / Call BLKCTR routine
                250                          / (totals # blocks written
                006                          / in bytes 03-372,03-373)
2  171          006             LAI  004    / Sets write a GAP bit
                004                          / high
2  173          123             OUT+22       / Output to COMMAND latch
2  174          006             LAI  000    / Resets write a GAP bit
                000
2  176          123             OUT+22       / Output to COMMAND latch
2  177          007         BLK,RET          / end of BLKSZ routine
```

Subroutine MRCDR.
Description. Called by time and data word format routines to write a 6-bit character on magnetic tape. Writes one character per call. Assumes character to be written is in SHIFT array byte location 03-360. Also samples CONSOLE SWITCHES for the value 000. When found, modifies routine BLKCTR to call ENDE routine to STOP at the end of the current block.
Entry point: 02-200
End of routine: 02-244
CPU Registers used: A,H,L
Reserved locations used: SHIFT array byte at 03-360
Input/Output ports used: INP+3, CONSOLE SWITCHES
OUT+22, COMMAND Latch Register
OUT+24, DATA Latch Register
Subroutines called: BLKSZ, STCK
Alternate entry points: None

```
2  200          056       MRCDR,LHI  003    / Set memory byte pointer
                003                          / to page 3, byte 360.
2  202          066             LLI  360    / Byte 360 contains 8-bit
                360                          / value for tape write.
2  204          307             LAM          / Move memory byte to A.
2  205          125             OUT+24       / Output to DATA latch
2  206          106             CAL  002  070 / Call STCK routine
                070                          / (test if recorder busy)
                002                          / (returns when NOT busy)
2  211          006             LAI  002    / Set recorder WRITE bit
                002                          / in command word.
2  213          123             OUT+22       / Output to COMMAND latch
2  214          006             LAI  000    / Reset recorder WRITE bit
                000                          / in command word.
2  216          123             OUT+22       / Output to COMMAND latch
2  217          106             CAL  002  140 / Call BLKSZ routine
                140                          / (adds 1 to the character
                002                          / count for current block)
2  222          107             INP+3        / Input CONSOLE Switches
2  223          074             CPI  000    / Are all bits zero?
                000                          / (STOP at end of block)
2  225          110             JFZ  002  241 / If not, jump to EXIT.
                241                          / (donot STOP at the end
                002                          / of this block)
2  230          056             LHI  006    / Set memory byte pointer
                006                          / to page 6, byte 265.
2  232          066             LLI  265    / Activates the auto end
                265                          / routine, ENDE.
```

```
2  234     076            LMI  342      / Store value 342.   ***
           342                          / (sets auto call to ENDE)
2  236     060            INL           / Increment byte pointer.
2  237     076            LMI  007      / Store value 007 (=RET)
           007                          / (inserts RET at 06-266)
2  241     056       EXIT,LHI  003      / Set memory page pointer
           003                          / to page 3.
2  243     007            RET           / end of MRCDR routine
2  244     000            HLT
```

Subroutine SHIFT.
Description. Treats SHIFT array locations 03-360 through 03-366 as a 56 bit left-shift register. Uses the register B to set the number of bits to be shifted on each call. The register D is used for internal control. The shifted result is left in SHIFT location 03-360.
Entry point: 02-260
End of routine: 02-303
CPU Registers used: A,B,D,H,L
Reserved locations used: SHIFT array locations 03-360 to 03-366
Input/Output ports used: None
Subroutines called: None
Alternate entry points: None

```
2  260     056      SHIFT,LHI  003      / Set memory byte pointer
           003                          / to page 3, byte 366.
2  262     036        SH2,LDI  007      / Set D= 007 for full
           007                          / ripple of all six words
2  264     066            LLI  366      / in SHIFT array at 03-360
           366                          / to 03-366. Value in reg
2  266     307        SH1,LAM           / B is # of bits shifted.
2  267     022            RAL           / Shift A one bit left
2  270     370            LMA           / Move A back to Memory
2  271     061            DCL           / Decrement page address
2  272     031            DCD           / Decrement D, # words.
2  273     110            JFZ  002 266  / Jump to SH1 until D
           266                          / words have been shifted
           002                          / one bit left.
2  276     011            DCB           / Decrement B, # bits
2  277     110            JFZ  002 262  / Jump to SH2 until all
           262                          / words have been shifted
           002                          / B bits.
2  302     007            RET           / end of SHIFT routine
2  303     000            HLT
```

Subroutine PACKER.
Description. Takes the ASCII coded time word in the TIME array at locations 03-200 through 03-217, masks for the low order four bits (HEX) and packs them two HEX digits per byte in the SHIFT array at 03-361 through 03-366.
Entry point: 02-320
End of routine: 02-377
CPU Registers used: A,B,C,H,L
Reserved locations used: TIME array at 03-200 to 03-217
SHIFT array at 03-361 to 03-366
Input/Output ports used: None

```
Subroutines called: None
Alternate entry points: None

2  320    066    PACKER,LLI  361      / Set memory byte pointer
          361                          / to page 3, byte 361.
2  322    056          LHI   003      / Converts ASCII digits
          003                          / to 4-bit HEX digits.
2  324    076          LMI   377      / Set byte 361=FF (hex)
          377                          / All other fills 1/2 byte
2  326    060          INL            / Increment byte pointer.
2  327    076          LMI   360      / Set byte 362=F0 (hex)
          360                          / High byte fill(11110000)
2  331    316          LBL            / Save SHIFT array ptr.
2  332    066          LLI   202      / Set byte pointer= 202,
          202                          / start of TIME word array
2  334    306          LAL            / Move L to A
2  335    326       CY1,LCL           / Save TIME array ptr.
2  336    044          NDI   001      / Mask with 00000001
          001                          / for even address test.
2  340    110          JFZ   002  364 / Jump to CY2 if on an
          364                          / odd byte address.
          002
2  343    307          LAM            / Get time word digit.
2  344    044          NDI   017      / Mask with 00001111
          017                          / to get low 4-bits.
2  346    361          LLB            / Get SHIFT array ptr.
2  347    267          ORM            / OR high/low half-bytes.
2  350    370          LMA            / Update SHIFT array byte.
2  351    060          INL            / Increment byte pointer.
2  352    316          LBL            / Store SHIFT array ptr.
2  353    362       CY3,LLC           / Get TIME array pointer.
2  354    060          INL            / Increment TIME pointer.
2  355    306          LAL            / Move L to A
2  356    074          CPI   213      / Does A= 213? The end of
          213                          / the TIME array bytes.
2  360    110          JFZ   002  335 / Jump to CY1 if not at
          335                          / the end of TIME array.
          002
2  363    007          RET            / end of PACKER routine
2  364    307          LAM            / Move odd time byte to A.
2  365    002       CY2,RLC           / Shift A one bit left
2  366    002          RLC            /          "
2  367    002          RLC            /          "
2  370    002          RLC            /          "
2  371    044          NDI   360      /  Mask A with 11110000
          360                          / Get high 4-bit byte.
2  373    361          LLB            / Get SHIFT array ptr.
2  374    370          LMA            / Store byte in SHIFT area
2  375    104          JMP   002  353 / Jump to CY3
          353
          002


Subroutine DPTFMT.
Description.  Converts data word HEX digits stored in SHIFT array
              at 03-361 through 03-366 into ASCII characters for
              printing on the TTY.
Entry point: 03-000
```

End of routine: 03-025
CPU Registers used: A,B,C,H
Reserved locations used: SHIFT array at 03-360 to 03-366

Input/Output ports used: None
Subroutines called: TPT (in TPTFMT at 01-332)
Alternate entry points: DPT at 03-007

```
3    0     056     DPTFMT,LHI  003       / Set memory byte pointer
               003                        / to page 3
3    2     106           CAL   006  100  / Call CRLF routine
               100                        / (gives a carriage return
               006                        / and line feed to TTY)
3    5     026           LCI   003        / Set reg C for the # of
               003                        / half-byte array shifts
3    7     016        DPT,LBI  004        / Set reg B for the # of
               004                        / bits shifted each call
3   11     106           CAL   002  260  / Call SHIFT routine to
               260                        / shift array B-bits,
               002                        / C-times
3   14     021           DCC              / Decrement reg C
3   15     110           JFZ   003  007   / Jump to DPT until reg
               007                        / C contains zero
               003
3   20     026           LCI   011        / Reset reg C to print
               011                        / 9 byte data word
3   22     104           JMP   001  332   / Jump to link TPT in
               332                        / TPTFMT routine (reuse
               001                        / of common coding)
3   25     000                            / end of DPTFMT routine.
3   26     000     / Next follows the array HOUSE containing the
3   27     000     / digital sub-multiplexer addresses to place
3   30     000     / the discrete bits associated with each analog
3   31     000     / channel in the data word that is generated in
3   32     000     / the write-to-recorder array, SHIFT.
3   33     000     / The last two digits of the array byte address
3   34     000     / form the analog channel address in octal.
3   35     000     / The array HOUSE extends from page 3, byte 100
3   36     000     / to page 3, byte 140.  The contents of bits
3   37     000     /  6, 5, and 4 control the selection of one-of-
3   40     000     / eight possible 8-bit discrete bytes as:
3   41     000     /                MSB                       LSB
3   42     000     /     OCTAL       7  6  5  4  3  2  1  0
3   43     000     /       000       0  0  0  0  0  0  0  0
3   44     000     /       020       0  0  0  1  0  0  0  0
3   45     000     /       040       0  0  1  0  0  0  0  0
3   46     000     /       060       0  0  1  1  0  0  0  0
3   47     000     /       100       0  1  0  0  0  0  0  0
3   50     000     /       120       0  1  0  1  0  0  0  0
3   51     000     /       140       0  1  1  0  0  0  0  0
3   52     000     /       160       0  1  1  1  0  0  0  0
3   53     000
3   54     000
3   55     000
3   56     000
3   57     000
3   60     000
3   61     000
3   62     000
3   63     000
```

```
3   64      000
3   65      000
3   66      000
3   67      000
3   70      000
3   71      000
3   72      000
3   73      000
3   74      000
3   75      000
3   76      000
3   77      000
3   100     140     / Channel 0, sub-mux address 6
                    / Ceilometer digital on discrete bytes.
3   101     000     / Channel 1, sub-mux address 0
3   102     000     / Channel 2, sub-mux address 0
3   103     000     / Channel 3, sub-mux address 0
3   104     020     / Channel 4, sub-mux address 1
3   105     000     / Channel 5, sub-mux address 0
3   106     000     / Channel 6, sub-mux address 0
3   107     000     / Channel 7, sub-mux address 0
3   110     000     / Channel 10, sub-mux address 0
3   111     000     / Channel 11, sub-mux address 0
3   112     000     / Channel 12, sub-mux address 0
3   113     000     / Channel 13, sub-mux address 0
3   114     000     / Channel 14, sub-mux address 0
3   115     000     / Channel 15, sub-mux address 0
3   116     000     / Channel 16, sub-mux address 0
3   117     120     / Channel 17, sub-mux address 5
                    / Rain Gauge digital on discrete bytes
3   120     040     / Channel 20, sub-mux address 2
3   121     040     / Channel 21, sub-mux address 2
3   122     020     / Channel 22, sub-mux address 1
3   123     000     / Channel 23, sub-mux address 0
3   124     040     / Channel 24, sub-mux address 2
3   125     040     / Channel 25, sub-mux address 2
3   126     000     / Channel 26, sub-mux address 0
3   127     000     / Channel 27, sub-mux address 0
3   130     100     / Channel 30, sub-mux address 4
3   131     060     / Channel 31, sub-mux address 3
3   132     060     / Channel 32, sub-mux address 3
3   133     060     / Channel 33, sub-mux address 3
3   134     060     / Channel 34, sub-mux address 3
3   135     000     / Channel 35, sub-mux address 0
3   136     100     / Channel 36, sub-mux address 4
3   137     100     / Channel 37, sub-mux address 4
3   140     000     / ---- end of HOUSE array ----
3   141     000
3   142     000
3   143     000
3   144     000
3   145     000
3   146     000
3   147     000
3   150     000
3   151     000
3   152     000
3   153     000
3   154     000
```

```
3  155     000
3  156     000
3  157     000
3  160     000
3  161     000
3  162     000
3  163     000
3  164     000
3  165     000
3  166     000
3  167     000
3  170     000    / Next follows the storage array TIME, used to
3  171     000    / hold the ASCII time word transmitted on the
3  172     000    / 488 Interface Buss from the digital clock to
3  173     000    / the data logger.  Each byte of the array
3  174     000    / stores one ASCII character.  The order in
3  175     000    / which the time word is stored is given aside
3  176     000    / of each byte.
3  177     000
3  200     040    / The ASCII character SP(signals start of word)
3  201     040    / The ASCII character SP also
3  202     XXX    / The 100s day-of-year digit.
3  203     XXX    / The 10s day-of-year digit.
3  204     XXX    / The units day-of-year digit.
3  205     XXX    / The 10s of hours digit.
3  206     XXX    / The unit hours digit.
3  207     XXX    / The 10s of minutes digit.
3  210     XXX    / The unit minutes digit.
3  211     XXX    / The 10s of seconds digit.
3  212     XXX    / The unit seconds digit.
3  213     015    / ASCII carriage return character.
3  214     012    / ASCII line feed character.
3  215     040    /  ---- end of TIME array ----
3  216     040
3  217     060    / Special register and flag locations follow:
3  220     XXX    / Flag register for SCAN analog channels ON/OFF
3  221     XXX    / TIME TAG flag register.
3  222     XXX    / Analog channel REQUEST array pointer.
3  223     000
3  224     000
3  225     000
3  226     000
3  227     000    / ASCII DATA array bytes follow.
3  230     017    / Data word sync character, =
3  231     XXX    / High digit of anaalog channel address, BCD.
3  232     XXX    / Low digit of analog channel address, BCD.
3  233     XXX    / Upper four discrete channel bits, BCD.
3  234     XXX    / Lower four discrete channel bits, BCD.
3  235     XXX    / 1000s digit of A/D conversion, BCD.
3  236     XXX    / 100s digit of A/D conversion, BCD.
3  237     XXX    / 10s digit of A/D conversion, BCD.
3  240     XXX    / Units digit of A/D conversion, BCD.
3  241     330    / ---- end of DATA array ----
3  242     000
3  243     000
3  244     000
3  245     000
3  246     000
3  247     000
```

```
   3  250      000      / Next follows the array REQUEST which holds
   3  251      000      / the sampling request masks for each of the
   3  252      000      / 37 (octal) analog channels.  The routine
   3  253      000      / CHTEST compares each of these request masks
   3  254      000      / with the current sampling time mask in the
   3  255      000      / processor register E by ANDing these two
   3  256      000      / masks.  If one or more of the bits in the
   3  257      000      / two masks are the same, then the analog
   3  260      000      / channel addressed by the last two octal
   3  261      000      / digits of the byte location is sampled and
   3  262      000      / recorded on tape.  All 37 (octal) masks are
   3  263      000      / tested in sequence each time the MAIN program
   3  264      000      / initiates a data channel scan.
   3  265      000      / The eight bits of each REQUEST service mask
   3  266      000      / (coded as: MSB=7/6/5/4/3/2/1/0=LSB) requests
   3  267      000      / one or more of the sampling rates:
   3  270      000      / Bit 7 is not used.
   3  271      000      / Bit 6 is no rate, continue to next request.
   3  272      000      / Bit 5 rate, sample every 20 seconds (adjustable).
   3  273      000      / Bit 4 rate, every sec for 1/2 hour-odd hours
   3  274      000      / Bit 3 rate, 1 min for first 10 min of hour
   3  275      000      / Bit 2 rate, 1 sec for first 10 min of hour
   3  276      000      / Bit 1 rate, each minute continuously
   3  277      000      / Bit 0 rate, each second continuously
-------------------------------------------------------------------
                        / Channel use updated as of March, 1981
                          Last update, October, 1980
-------------------------------------------------------------------
   3  300      012      / Channel 0, bits 3 and 1 rates.
                        / AEG, Trailer-side unit
                        / Ceilometer on discrete bytes
                        / Tens digit = 100s of meters
                        / Unit digit = 10s of meters
   3  301      012      / Channel 1, bits 3 and 1 rates.
                        / Laser Scintillometer
   3  302      012      / Channel 2, bits 3 and 1 rates.
                        / N/U
   3  303      040      / Channel 3, bit 5 rate.
                        / AEG, 2 meter height
   3  304      012      / Channel 4, bits 3 and 1 rates.
                        / Eltro, horizontal path
                        / Eltro calibration periods given by:
                        / Discrete high digit = Slant-path Eltro
                        / Discrete low digit = Horizontal Eltro
   3  305      012      / Channel 5, bits 3 and 1 rates.
                        / Night Path Function Meter, Filter
   3  306      012      / Channel 6, bits 3 and 1 rates.
                        / Night Path Function Meter, Photopic
   3  307      012      / Channel 7, bits 3 and 1 rates.
                        / Night Path Function Meter, Range
   3  310      100      / Channel 10, bit 6 (continue scanning array)
                        / N/U
   3  311      040      / Channel 11, bit 5 rate.
                        / AEG, 8 meter height
   3  312      040      / Channel 12, bit 5 rate.
                        / AEG, 16 meter height
   3  313      040      / Channel 13, bit 5 rate.
                        / AEG, 48 meter height, analog
   3  314      012      / Channel 14, bits 3 and 1 rates.
```

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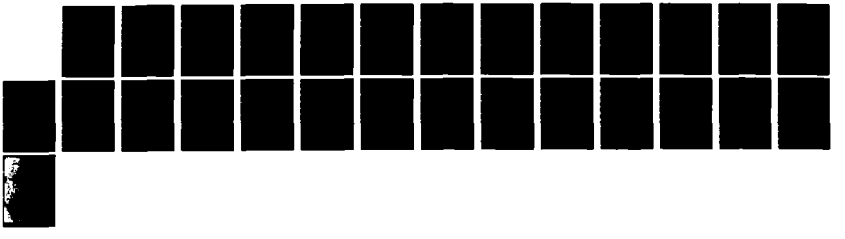
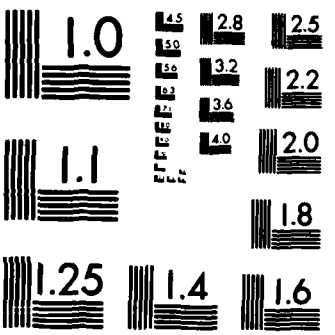
UNCLASSIFIED AFGL-TR-81-0130 F19628-78-C-0186 F/G 9/2 NL





```
                        / CO2 Laser, PAR output
3  315      012         / Channel 15, bits 3 and 1 rates.
                        / CO2 Laser, Power Meter output
3  316      012         / Channel 16, bits 3 and 1 rates.
                        / CO2 Laser, Angle output
                        / The two discrete digits represent the
                        / 10's and 1's counts of the Digital
                        / Rain Gauge.
3  317      012         / Channel 17, bits 3 and 1 rates.
                        / CO2 Laser, Gain output
                        / Low order discrete digit represents
                        / 100's count of the Digital Rain Gauge.
3  320      012         / Channel 20, bits 3 and 1 rates.
                        / Turbulence on 500M Barnes
3  321      012         / Channel 21, bits 3 and 1 rates.
                        / Barnes 500M Transmissometer
3  322      012         / Channel 22, bits 3 and 1 rates.
                        / Barnes 1500M Transmissometer
3  323      012         / Channel 23, bits 3 and 1 rates.
                        / Analog Rain Gauge
3  324      012         / Channel 24, bits 3 and 1 rates.
                        / Luxmeter, Horizontal Channel
3  325      040         / Channel 25, bit 5 rate.
                        / AEG, 80 meter height
3  326      012         / Channel 26, bits 3 and 1 rates.
                        / Eltro, slant path
3  327      100         / Channel 27, bit 6 (continue scanning array)
                        / N/U
3  330      012         / Channel 30, bits 3 and 1 rates.
                        / A/D Converter Reference Channel
3  331      020         / Channel 31, bit 4 rate.
                        / Scanning Nephelometer, Angle
3  332      020         / Channel 32, bit 4 rate.
                        / Scanning Nephelometer, Scale Shift
3  333      020         / Channel 33, bit 4 rate.
                        / Scanning Nephelometer, Photo Diode
3  334      020         / Channel 34, bit 4 rate.
                        / Scanning Nephelometer, Monitor
3  335      100         / Channel 35, bit 6 (continue scanning array)
                        / N/U
3  336      012         / Channel 36, bits 3 and 1 rates.
                        / Eppley, Direct Channel
3  337      012         / Channel 37, bits 3 and 1 rates.
                        / Laser Scintillometer, DC Monitor
                        / The Sun Sensor is recorded on the high-
                        / order discrete channel digit.
3  340      000         / Trap value, signals software end-of-array
3  341      000         / ----------end of REQUEST array----------
3  342      000
3  343      000
3  344      000
3  345      000
3  346      000
3  347      000
3  350      000
3  351      000
3  352      000       / Next follows the array SHIFT used by the
3  353      000       / routine SHIFT to position and format the
3  354      000       / the 6-byte contents into the byte 360.
```

```
3  355     000
3  356     000
3  357     000
3  360     XXX    / Formatted byte left here for print or write
3  361     XXX    / Byte 0
3  362     XXX    / Byte 1
3  363     XXX    / Byte 2
3  364     XXX    / Byte 3
3  365     XXX    / Byte 4
3  366     XXX    / Byte 5
3  367     000    / ---------end of SHIFT array--------------
3  370     XXX    / Upper byte of BLKSZ counter for BLKSZ routine
3  371     XXX    / Lower byte of BLKSZ counter for BLKSZ routine
3  372     XXX    / Upper byte of number of blocks written counter
3  373     XXX    / Lower byte of number of blocks written counter
3  374     000
3  375     000
3  376     000    / Character pointer register
3  377     000    / TYMSYN counter
```

Subroutine DIGMUX.
Description. Loads the SHIFT array with the data word by packing and formating the analog channel address, discrete bits, and the A/D converter output in the locations 03-361 through 03-366.
Entry point: 04-000
CPU Registers used: A,B,D,H,L
Reserved locations used: SHIFT array from 03-360 to 03-366
Input/Output ports used: INP+4, RECORDER/A-D Status
INP+10, INPUT DIGITAL MULTIPLEXER
OUT+30, DIGMUX ADDRESS Latch Register
Subroutines called: LOADER
Alternate entry points: None

```
4   0     056     DIGMUX,LHI  003       / Set memory byte pointer
          003                           / to page 3, byte 222.
4   2     105       BUSY,INP+4          / Input A/D status bit.
4   3     044            NDI  040       / Mask with 00100000
          040                           / to test STATUS.
4   5     150            JTZ  004  002  / Jump to BUSY if A/D
          002                           / in conversion process.
          004
4   10    066            LLI  222       / Point to the REQUEST
          222                           / array pointer location.
4   12    307            LAM            / Get REQUEST value.
4   13    044            NDI  177       / Mask with 01111111 to
          177                           / get HOUSE array address
4   15    310            LBA            / Save HOUSE pointer in B
4   16    066            LLI  362       / Set byte pointer to 1st
          362                           / byte in SHIFT array.
4   20    076            LMI  015       / Load with start of data
          015                           / word character. =
4   22    060            INL            / Increment byte pointer.
4   23    006            LAI  000       / Set digital MUX address
          000                           / to analog channel byte.
4   25    131            OUT+30         / Output to DIGITAL MUX.
4   26    111            INP+10         / Input DIGITAL MUX byte.
```

```
4   27      370             LMA             / Store in SHIFT byte.
4   30      060             INL             / Point to next byte.
4   31      301             LAB             / Get HOUSE array value.
4   32      316             LBL             / Temp save L in B.
4   33      360             LLA             / Load sub-MUX address.
4   34      307             LAM             / Sets up for discretes.
4   35      064             ORI  002        / Sets bit 1 in digital
            002                             / register for discretes.
4   37      131             OUT+30          / Output to DIGITAL MUX.
4   40      111             INP+10          / Input discretes byte.
4   41      361             LLB             / Get saved byte pointer.
4   42      370             LMA             / Load discretes to SHIFT
4   43      016             LBI  003        / Set counter for 2 A/D
            003                             / bytes.
4   45      060         DAT,INL             / Increment byte pointer.
4   46      301             LAB             / Get saved pointer.
4   47      131             OUT+30          / Output to DIGITAL MUX
4   50      111             INP+10          / Input next SHIFT byte.
4   51      370             LMA             / Store byte in SHIFT.
4   52      010             INB             / Increment counter.
4   53      301             LAB             / Get counter value.
4   54      074             CPI  005        / Compare with 5.
            005
4   56      110             JFZ  004  045   / Jump to DAT if less
            045                             / than 5.
            004
4   61      106             CAL  007  000   / Call LOADER routine.
            000                             / (loads circular buffer
            007                             / with last 256 bytes)
4   64      007             RET             / end of DIGMUX routine.
4   65      000             HLT
```

Subroutine TWTFMT.
Description. Formats and writes the time word stored in SHIFT array to the magnetic tape in HEX coding.
Entry point: 04-100
End of routine: 04-133
CPU Registers used: A,B,C,H,L
Reserved locations used: SHIFT array from 03-360 to 03-366
Input/Output ports used: None
Subroutines called: LDLINK, SHIFT, MRCDR
Alternate entry points: TWT at 04-107

```
4   100     106     TWTFMT,CAL  007  050 / Call LDLINK routine.
            050                         / (links to PACKER and
            007                         / LOADER routines)
4   103     056             LHI  003    / Set memory byte pointer
            003                         / to page 3.
4   105     026             LCI  010    / Set # of time word bytes
            010                         / to fix # calls to SHIFT.
4   107     016         TWT,LBI  006    / Set # of bits shifted on
            006                         / each call to SHIFT.
4   111     106             CAL  002  260 / Call SHIFT routine.
            260                         / (positions 6-bit value
            002                         / in SHIFT array byte 0)
4   114     066             LLI  360    / Point to byte 360,
            360                         / on page 3.
4   116     307             LAM         / Get byte to be written.
```

```
4  117     106           CAL  002  200 / Call MRCDR routine.
           200                        / (writes 6-bit value from
           002                        / SHIFT array to mag tape)
4  122     021           DCL           / Decrement # bytes ctr.
4  123     110           JFZ  004  107 / Jump TWT until all C
           107                        / bytes are written.
           004
4  126     066           LLI  221      / Reset TIME TAG ON/OFF
           221                        / flag to OFF.
4  130     076           LMI  000      / Do it.
           000
4  132     007           RET           / end of TWTFMT routine.
4  133     000           HLT
```

Subroutine DWTFMT.
Description. Formats and writes data word stored in SHIFT array to magnetic tape in HEX coding.
Entry point: 04-140
End of routine: 04-162
CPU Registers used: B,C,H
Reserved locations used: SHIFT array locations 03-360 to 03-366
Input/Output ports used: None
Subroutines called: SHIFT, TWT (in TWTFMT at 04-107)
Alternate entry points: DWT at 04-144

```
4  140     056     DWTFMT,LHI  003      / Set memory byte pointer
           003                          / to page 3.
4  142     026         LCI  002         / Set # of uses of SHIFT
           002                          / routine for data word.
4  144     016       DWT,LBI  006       / Set # of bits shifted on
           006                          / each use of SHIFT.
4  146     106         CAL  002  260    / Call SHIFT routine.
           260
           002
4  151     021         DCC              / Decrement # use counter.
4  152     110         JFZ  004  144    / Jump to DWT until bytes
           144                          / 0 and 1 in SHIFT array
           004                          / have been skipped.
4  155     026         LCI  006         / Set # of SHIFT array
           006                          / bytes to be written.
4  157     104         JMP  004  107    / Jump to TWTFMT routine.
           107                          / (reuses coding to write
           004                          / data word to tape)
4  162     000                          / end of DWTFMT routine.
4  163     000         HLT
```

Subroutine CLEAR.
Description. Initializes all pointers, counters, and reserved bytes. Sets all output latch registers to zero.
Entry point: 04-200
End of routine: 04-307
CPU Registers used: A,E,H,L
Reserved locations used: All
Input/Output ports used: OUT+20, OUTPUT to TTY Latch Register
OUT+22, COMMAND Latch Register
OUT+24, DATA OUTPUT Latch Register
OUT+26, ANALOG ADDRESS Latch Register

```
                                OUT+30, DIGITAL ADDRESS Latch Register
                                OUT+32, 488 CONTROL BUSS Latch Register
                                OUT+34, EXPERIMENT COMMAND Latch Register
                                OUT+36, 488 DATA BUSS Latch Register
Subroutines called: None
Alternate entry points: None

4  200     056       CLEAR,LHI  004       / Set memory byte pointer
           004                             / to page 4, byte 210 to
4  202     066             LLI  210       / allow contents to be
           210                             / changed by the program.
4  204     046             LEI  366       / Set counter, E, for
           366                             / count up sequence.
4  206     006         LOC,LAI  000       / Output 00000000 to all
           000                             / output registers.
4  210     121             OUT+22         / CLEAR output register.
4  211     307             LAM            / Get output port address.
4  212     004             ADI  002       / Add 2 to address the
           002                             / output port.
4  214     370             LMA            / Store new output address
4  215     040             INE            / Increment counter, E.
4  216     110             JFZ  004  206  / Jump to LOC until count
           206                             / reaches zero.
           004
4  221     076             LMI  121       / Restore original code
           121                             / value to byte 210.
4  223     056             LHI  003       / Set memory byte pointer
           003                             / to page 3, byte 377.
4  225     066             LLI  377       / Set TYMSYC counter to
           377                             / zero.
4  227     076             LMI  000       / Do it.
           000
4  231     066             LLI  222       / Set channel pointer
           222                             / value at byte 222
4  233     076             LMI  277       / to REQUEST array start
           277                             / -1 location.
4  235     066             LLI  221       / Set TIME TAG flag to
           221                             / the ON value.
4  237     076             LMI  077       / Do it.
           077
4  241     066             LLI  370       / Set BLKSZ counter, high
           370                             / byte, to 010.
4  243     076             LMI  010       / Do it.
           010
4  245     066             LLI  371       / Set BLKSZ counter, low
           371                             / byte, to 376.
4  247     076             LMI  376       / Do it.
           376
4  251     056             LHI  002       / Change code at page 2,
           002                             / byte 200 to 056 and
4  253     066             LLI  200       / restore tape recorder
           200                             / driver routine to
4  255     076             LMI  056       / operation.
           056
4  257     056             LHI  003       / Clear BLKCTR, high
           003                             / byte to zero.
4  261     066             LLI  372
           372
4  263     076             LMI  000       / Do it.
```

```
                000
4   265         060             INL             / Increment byte pointer.
4   266         076             LMI     000     / Clear BLKCTR  low
                000                             / byte to zero.
4   270         056             LHI     006     / Restores call in BLKCTR
                006                             / to STCK which is changed
4   272         066             LLI     265     / by calls to ENDE.
                265
4   274         076             LMI     070     / Do it.
                070
4   276         060             INL             / Increment byte pointer.
4   277         076             LMI     002     / Complete restoration
                002                             / of machine code.
4   301         056             LHI     005     / Restore code in MDUMP
                005                             / to call for CRLF.
4   303         066             LLI     343     / Set memory byte pointer
                343                             / to page 5, byte 343.
4   305         076             LMI     106     / Restore CAL(=106) code.
                106
4   307         007             RET             / end of CLEAR routine.


Program VERIFY.
Description.  Starting with the lowest memory byte, the stored
              value is compared with the value on the paper tape
              which is assumed to be correct.  If the two values
              agree, the next byte is tested against the tape
              value.  If the values disagree, the tape value is
              loaded into the memory byte.  All "corrections" are
              printed out on the TTY to aid in locating possible
              defective memory bytes.
Entry point: 04-310
End of routine: 04-371
CPU Registers used: A,D,E,H,L
Reserved locations used: None
Input/Output ports used: None
Subroutines called: RDRCNTL, RDROFF, ERRPRNT
Alternate entry points: None

4   310         106     VERIFY,CAL  006  171 / Call RDROFF routine.
                171                         / (turns paper tape reader
                006                         / OFF on TTY)
4   313         056             LHI     005 / Set memory byte pointer
                005                         / to page 5, byte 343.
4   315         066             LLI     343 / Defeats call to CRLF in
                343                         / MDUMP routine to allow
4   317         076             LMI     007 / reuse of coding.
                007
4   321         056             LHI     000 / Set memory byte pointer
                000                         / to page 0, byte 000.
4   323         066             LLI     000 / Starts loading and
                000                         / comparison at lowest
4   325         106       JMP1,CAL  006  161 / Call RDRCNTL routine.
                161                         / (turns TTY paper tape
                006                       / reader ON for one byte)
4   330         074             CPI     000 / Is byte= 000?  If so,
                000                       / still on "leader".
4   332         150             JTZ     004  325 / Jump to JMP1 until first
                325                         / non-zero byte is read.
```

```
                004
4   335         277         JMP4,CPM                / Compare memory byte with
4   336         150              JTZ   004   346  / tape byte.  If not the
                346                                 / same, replace with tape
                004                                 / byte value.
4   341         106              CAL   005   050  / Call ERRPRNT routine.
                050                                 / (prints memory location,
                005                                 / old value and new value)
4   344         353              LHD                / Restore pointer H from D
4   345         364              LLE                / Restore pointer L from E
4   346         060         JMP2,INL                / Increment byte pointer.
4   347         110              JFZ   004   362  / Jump to JMP3 until L=0.
                362
                004
4   352         050              INH                / Go to next page.
4   353         305              LAH                / If not on last page of
4   354         074              CPI   010          / memory continue. If page
                010                                 / is greater than 7, STOP.
4   356         110              JFZ   004   362  / Jump to JMP3 until page
                362                                 / has been compared.
                004
4   361         000              HLT                / STOP after page 7.
4   362         106         JMP3,CAL   006   161  / Call RDRCNTL routine.
                161                                 / (reads a single byte
                006                                 / from the tape)
4   365         104              JMP   004   335  / Jump to JMP4 to continue
                335                                 / memory byte vs tape
                004                                 / byte comparison.
4   370         000              HLT                / end of VERIFY routine.
```

Subroutine BINLD.
Description. Loads binary tapes punched in memory image format by the program PDUMP. First non-blank byte on the paper tape is loaded to memory page 00, byte 000, and byte loading into higher memory bytes continues until end of tape.
Entry point: 05-000
End of routine: 05-035
CPU Registers used: A,H,L
Reserved locations used: None
Input/Output ports used: INP+0, INPUT from TTY
OUTPUT+22, COMMAND Latch Register
Subroutines called: RDY
Alternate entry point: None

```
5    0          056        BINLD,LHI   000       / Set memory byte pointer
                000                               / to page 0, byte 000.
5    2          066             LLI   000       / Loads lowest memory
                000                               / byte from paper tape.
5    4          006             LAI   001       / Turn on paper tape
                001                               / reader command.
5    6          123             OUT+22           / Output to COMMAND reg.
5    7          106          BL1,CAL   005   036  / Call RDY routine
                036                               / (tests for TTY status,
                005                               /  returns when READY)
5   12          101             INP+0            / Input TTY 8-bit byte.
```

```
5   13      074             CPI  000        / Test for 1st non-zero
            000                             / byte.
5   15      150             JTZ  005  007   / Jump to BL1 if byte is
            007                             / zero, still on paper
            005                             / tape "leader".
5   20      370         BL3,LMA             / Store byte in memory.
5   21      060             INL             / Increment byte pointer.
5   22      110             JFZ  005  026   / Jump to BL2 if not at
            026                             / the end of the current
            005                             / page.
5   25      050             INH             / Increment page pointer.
5   26      106         BL2,CAL  005  036   / Call RDY routine.
            036                             / (tests status of TTY)
            005
5   31      101             INP+0           / Input TTY byte.
5   32      104             JMP  005  020   / Jump to BL3 and continue
            020                             / sequential loading of
            005                             / memory from paper tape.
5   35      000             HLT             / end of BINLD routine.


Subroutine RDY
Description. Tests TTY for data available from TTY.
Entry point: 05-036
End of routine: 05-047
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: INP+2, RECORDER/A-D/TTY Status
Subroutines called: None
Alternate entry points: None

5   36      103         RDY,INP+2           / Input TTY STATUS reg.
5   37      044             NDI  040        / Mask with 00100000 to
            040                             / test for Data Available.
5   41      022             RAL             / Rotate left one bit.
5   42      022             RAL             / Rotate left one bit
5   43      022             RAL             / Rotate left one bit
5   44      100             JFC  005  036   / Jump to RDY until data
            036                             / is available, i.e., bit
            005                             / in carry is one.
5   47      007             RET             / end of RDY routine.


Subroutine ERRPRNT
Description.  A routine to format and print page, byte number,
              contents of memory byte in error, and corrected
              contents.
Entry point: 05-050
End of routine: 05-077
CPU Registers used: A,D,E,H,L
Reserved locations used: None
Input/Output ports used: None
Subroutines called: PUSH A, POP A, MDP, PRDY, CRLF, MEMDIG
Alternate entry points: None

5   50      335   ERRPRNT,LDH           / Store page pointer in D.
5   51      346             LEL         / Store byte pointer in E.
5   52      106             CAL  006  360 / Call PUSH A routine.
            360                         / Temporary stack to store
```

```
                006                                 / register A value.
5    55         106             CAL   005   302    / Call MDP entry in MDUMP
                302                                 / routine.
                005
5    60         106             CAL   006   366    / Call POP A routine to
                366                                 / restore register A.
                006
5    63         353             LHD                / Get bad address location
5    64         364             LLE                / saved in registers D,E.
5    65         370             LMA                / Replace bad memory byte.
5    66         106             CAL   005   325    / Call MEMDIG link in
                325                                 / MDUMP routine for space
                005                                 / and print memory byte.
5    71         106             CAL   006   100    / Call CRLF routine.
                100                                 / (gets a carriage return
                006                                 / and line feed on TTY)
5    74         106             CAL   005   136    / Call PRDY routine.
                136                                 / (tests for printer
                005                                 / ready status)
5    77         007             RET                / end of ERRPRNT routine.
```

Program PDUMP

Description. Punches binary tape in memory image format starting at 00-000 through 07-377. A blank tape "leader" and "trailer" section is also punched. Tapes punched with this program can be reloaded using the program BINLD.

Entry point: 05-100
End of routine: 05-135
CPU Registers used: A,H,L
Reserved locations used: None
Input/Output ports used: OUT+20, OUTPUT to TTY
Subroutines called: PRDY, LDTR
Alternate entry points: None

```
5    100        056          PDUMP,LHI  000       / Set memory byte pointer
                000                                 / to page 0, byte 000.
5    102        066               LLI   000
                000
5    104        106            PD1,CAL   005   136 / Call PRDY routine.
                136                                 / (tests for printer
                005                                 / ready status)
5    107        106               CAL   005   147 / Call LDTR routine.
                147                                 / (punches 64 blanks for
                005                                 / paper tape "leader")
5    112        106            PD2,CAL   005   136 / Call PRDY routine.
                136                                 / (tests for paper tape
                005                                 / punch status)
5    115        307               LAM               / Load memory byte to A.
5    116        121               OUT+20            / Output to TTY punch.
5    117        060               INL               / Increment byte pointer.
5    120        110               JFZ   005   112   / Jump to PD2 if not at
                112                                 / the end of the current
                005                                 / page.
5    123        050               INH               / Increment page pointer.
5    124        305               LAH               / Get page pointer value.
5    125        074               CPI   010         / Test for last page.
                010
```

```
5  127     110            JFZ  005  112 / Jump to PD2 until last
           112                         / page is punched.
           005
5  132     106            CAL  005  147 / Call LDTR routine.
           147                         / (punches 64 blanks for
           005                         / tape "trailer")
5  135     000            HLT           / end of PDUMP routine.


Subroutine PRDY
Description.  Tests if TTY is ready for printing and punching.
Entry point: 05-136
End of routine: 05-146
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: INP+2, RECORDER/A-D/TTY Status
Subroutines called: None
Alternate entry points: None

5  136     103       PRDY,INP+2         / Input TTY status.
5  137     044            NDI  002      / Mask with 00000010 to
           002                         / test for punch busy.
5  141     032            RAR           / Rotate right one bit.
5  142     032            RAR           / Rotate right one bit.
5  143     100            JFC  005  136 / Jump to PRDY until
           136                         / paper tape punch is
           005                         / idle.
5  146     007            RET           / end of PRDY routine.


Subroutine LDTR
Description.  Punches 64 blank bytes on paper tape for use as a
              "leader" or a "trailer" section.
Entry point: 05-147
End of routine: 05-163
CPU Registers used: A,B
Reserved locations used: None
Input/Output ports used: OUT+20, OUTPUT to TTY
Subroutines called: PRDY
Alternate entry points: None

5  147     016       LDTR,LBI  077      / Set # of blanks to
           077                         / be punched.
5  151     106        LD1,CAL  005  136 / Call PRDY routine.
           136                         / (tests for paper tape
           005                         / punch ready)
5  154     006            LAI  000      / Loads blank byte value.
           000
5  156     121            OUT           / Punch it.
5  157     011            DCB           / Decrement counter.
5  160     110            JFZ  005  151 / Jump to LD1 until all 8
           151                         / bytes have been punched.
           005
5  163     007            RET           / end of LDTR routine.
5  164     000            HLT


Subroutine ...'IN
Description.  Packs three consecutive ASCII digits entered from
```

```
                the keyboard into three octal digits.  The octal
                byte is left in register B on return.
Entry point: 05-200
End of routine: 05-251
CPU Registers used: A,B,C
Reserved locations used: None
Input/Output ports used: INP+0, INPUT from TTY
                         OUT+20, OUTPUT to TTY
Subroutines called: RDY
Alternate entry points: PROCS (at 05-205)

5  200     104     PROGIN,JMP  005  252 / Jump to ASTK routine.
           252                          / (character test
           005                          / routine, p/o test prog.)
5  203     101           INP+0          / Input byte from TTY.
5  204     121           OUT+20         / Output byte to TTY.
5  205     026     PROCS,LCI  006       / Set shift counter.
           006
5  207     002       RC1,RLC            / Shift input byte left.
5  210     021           DCC            / Decrement shift counter.
5  211     110           JFZ  005  207  / Jump to RC1 until C
           207                          / left shifts are carried
           005                          / out.
5  214     044           NDI  300       / Mask with 11000000 to
           300                          / set 2 highest bits.
5  216     310           LBA            / Store in register B.
5  217     106           CAL  005  036  / Call RDY routine.
           036                          / (tests for TTY status)
           005
5  222     101           INP+0          / Input TTY byte.
5  223     121           OUT+20         / Output TTY byte (echo)
5  224     026           LCI  003       / Set shift counter.
           003
5  226     002       RC2,RLC            / Rotate left  one bit.
5  227     021           DCC            / Decrement shift counter.
5  230     110           JFZ  005  226  / Jump to RC2 until C
           226                          / shifts have been carried
           005                          / out.
5  233     044           NDI  070       / Mask with 00111000 to
           070                          / middle 3 bits.
5  235     261           ORB            / OR with value in B.
5  236     310           LBA            / Store in register B.
5  237     106           CAL  005  036  / Call RDY routine.
           036                          / (tests for TTY ready)
           005
5  242     101           INP+0          / Input TTY byte.
5  243     121           OUT+20         / Output TTY byte (echo)
5  244     044           NDI  007       / Mask with 00000111 to
           007                          / set lowest 3 bits.
5  246     261           ORB            / OR with value in B.
5  247     007           RET            / end of PROGIN routine.
5  250     000           HLT
5  251     000           HLT


Subroutine ASTK.
Description.  Tests for input character * (=107)
Entry point: 05-252
End of routine: 05-270
```

```
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: INP+0, INPUT from TTY
                         OUT+20, OUTPUT to TTY
Subroutine called: RDY   OUT+20, OUTPUT to TTY
Alternate entry points: None 20, OUTPUT to TTY

5  252     106       ASTK,CAL  005  036 / Call RDY routine.
           036                          / (tests for TTY status)
           005
5  255     101            INP+0         / Input TTY byte.
5  256     121            OUT+20        / Output TTY byte.
5  257     074            CPI  107      / Is byte value =107(G)?
           107
5  261     150            JTZ  005  267 / Jump to LDAM if byte =G.
           267
           005
5  264     104            JMP  005  205 / Jump to PROCS link in
           205                          / PROGIN routine.
           005
5  267     307       LDAM,LAM           / Load memory value to A.
5  270     007            RET           / end of ASTK routine.
5  271     000            HLT


Program MDUMP.
Description. Formats and prints the contents of the currently
             addressed memory page starting at the current value
             of the memory byte pointer and continues to byte 377.
             Each octal byte is converted to three ASCII digits
             for printing through calls to PNTBIN.
Entry point: 05-300
End of routine: 05-355
CPU Registers used: A,D,E,H,L
Reserved locations used: None
Input/Output ports used: None
Subroutines called: PNTBIN, SPACE, CRLF
Alternate entry points: MDP (at 05-302)
                        MEMDIG (at 05-325)

5  300     335       MDUMP,LDH          / Save reg H in reg D.
5  301     346            LEL           / Save reg L in reg E.
5  302     056         MDP,LHI  003      / Set memory byte pointer
           003                          / to page 3, byte 361.
5  304     066            LLI  361
           361
5  306     373            LMD           / Store D in Memory.
5  307     106            CAL  006  000 / Call PNTBIN routine.
           000                          / (prints octal equivalent
           006                          / of SHIFT array byte 360)
5  312     106            CAL  005  356 / Call SPACE routine.
           356                          / (outputs 2 spaces on
           005                          / TTY line)
5  315     056            LHI  003      / Set memory byte pointer
           003                          / to page 3, byte 361.
5  317     066            LLI  361
           361
5  321     374            LME           / Store reg E at reg M.
5  322     106            CAL  006  000 / Call PNTBIN routine.
```

```
                000
                006                                     / (prints contents of page
                                                        / 3, byte 360 in octal)
5  325          106     MEMDIG,CAL  005  356 / Call SPACE routine.
                356                                     / (prints 2 spaces on the
                005                                     / current line)
5  330          353             LHD                     / Set memory byte pointer
5  331          364             LLE                     / to page D, byte E.
5  332          307             LAM                     / Store byte value in A.
5  333          056             LHI  003                / Set memory byte pointer
                003                                     / to page 3, byte 361.
5  335          066             LLI  361
                361
5  337          370             LMA                      / Store reg A at reg M.
5  340          106             CAL  006  000  / Call PNTBIN routine.
                000                                     / (prints memory byte
                006                                     / value in octal)
5  343          106             CAL  006  100  / Call CRLF routine..
                100                                     / (generates a carriage
                006                                     / return and a line feed)
5  346          040             INE                     / Increment reg E.
5  347          304             LAE                     / Transfer E to A.
5  350          074             CPI  000                / Is value=0?
                000
5  352          110             JFZ  005  302 / Jump to MDP until end
                302                                     / of current page.
                005
5  355          000             HLT                     / end of MDUMP routine.
```

Subroutine SPACE.
Description. Outputs two space commands to to TTY.
Entry point: 05-356
End of routine: 05-372
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: OUT+20, OUTPUT to TTY
Subroutines called: PRDY
Alternate entry points: None

```
5  356          106      SPACE,CAL  005  136 / Call PRDY routine.
                136                                     / (tests TTY status)
                005
5  361          006             LAI  040                / Load ASCII value for
                040                                     / space one character.
5  363          121             OUT+20                  / Do it.
5  364          106             CAL  005  136 / Call PRDY routine.
                136
                005
5  367          006             LAI  040                / Load ASCII value for
                040                                     / space one character.
5  371          121             OUT+20                  / Print it.
5  372          007             RET                     / end of SPACE routine.
5  373          000             HLT
```

Subroutine PNTBIN.
Description. Prints the ASCII equivalent of the octal contents

```
                of SHIFT array location 03-360.
Entry point: 06-000
End of routine: 06-037
CPU Registers used: A,B,C,D,H,L
Reserved locations used: SHIFT array byte at 03-360
Input/Output ports used: None
Subroutines called: FORMAT
Alternate entry points: None

6    0     016     PNTBIN,LBI  002       / Set # of bits shifted
               002                        / by SHIFT routine.
6    2     056           LHI   003       / Set memory byte pointer
               003                        / to page 3, byte 367.
6    4     066           LLI   367       / Temporary storage byte.
               367
6    6     373           LMD             / Save register D value.
6    7     026           LCI   003       / Mask (=0000011) for high
               003                        / two bits of byte 360.
6   11     106           CAL   006  040  / Call FORMAT routine.
               040                        / (converts octal byte
               006                        / to ASCII and prints it)
6   14     016           LBI   003       / Set # of bits shifted.
               003
6   16     026           LCI   007       / Mask (=00000111) for 3
               007                        / middle bits of byte 360.
6   20     106           CAL   006  040  / Call FORMAT routine.
               040
               006
6   23     016           LBI   003       / Sets # of bits shifted.
               003
6   25     026           LCI   007       / Mask (=00000111) for 3
               007                        / low bits of byte 360.
6   27     106           CAL   006  040  / Call FORMAT routine.
               040
               006
6   32     056           LHI   003       / Set memory byte pointer
               003                        / to page 3, byte 367.
6   34     066           LLI   367       / Temporary storage byte.
               367
6   36     337           LDM             / Restore value to reg D.
6   37     007           RET             / end of PNTBIN routine.


Subroutine FORMAT.
Description.  Converts low-order three bits at 03-360 in SHIFT
              array to ASCII and prints the octal value.
Entry point: 06-040
End of routine: 06-061
CPU Registers used: A,B,H,L
Reserved locations used: SHIFT array  byte at 03-360
Input/Output ports used: OUT+20, OUTPUT to TTY
Subroutines called: PRDY, SHIFT
Alternate entry points: None

6   40     106     FORMAT,CAL  002  260  / Call SHIFT routine.
               260                        / (shifts array SHIFT 8
               002                        / bits)
6   43     066           LLI   360       / Set byte pointer.
               360
```

```
6   45      056             LHI  003      / Page 3, byte 360 is 1st
            003                              / byte of array SHIFT.
6   47      307             LAM           / Get byte 360.
6   50      242             NDC           / Mask for bits = C mask.
6   51      064             ORI  260      / Convert to ASCII value.
            260
6   53      310             LBA           / Temporary save A in B.
6   54      106             CAL  005  136 / Call PRDY routine.
            136                           / (tests for TTY printer
            005                           / ready)
6   57      301             LAB           / Get saved A value in B.
6   60      121             OUT+20        / Print it.
6   61      007             RET           / end of FORMAT routine.
6   62      000             HLT
```

Subroutine CRLF.
Description. Outputs the carriage return command (015), delays three NOP periods (60 microseconds), outputs the line feed command (012), and delays two NOP periods (40 microseconds).
Entry point: 06-100
End of routine: 06-122
CPU Registers used: A
Reserved locations used: None
Input/Output ports used: OUT+20, OUTPUT to TTY
Subroutines called: PRDY
Alternate entry points: None

```
6   100     300       CRLF,LAA            / Nop (time delay)
6   101     106             CAL  005  136 / Call PRDY routine.
            136                           / (tests for TTY print
            005                           /  ready)
6   104     006             LAI  015      / Load ASCII value for
            015                           / carriage return.
6   106     121             OUT+20        / Print it.
6   107     300             LAA           / Nop (time delay)
6   110     300             LAA           / Nop (time delay)
6   111     300             LAA           / Nop (time delay)
6   112     106             CAL  005  136 / Call PRDY routine.
            136                           / (tests for printer
            005                           / ready)
6   115     006             LAI  012      / Load ASCII value for
            012                           / line feed.
6   117     121             OUT+20        / Print it.
6   120     300             LAA           / Nop (time delay)
6   121     300             LAA           / Nop (time delay)
6   122     007             RET           / end of CRLF routine.
6   123     000             HLT
```

Subroutine TYMTAG.
Description. Called by QLOOK to change page pointer to 076, and find the first ? character to synchronize printout of last 256 bytes recorded on magnetic tape.
Entry point: 06-140
End of routine: 06-160
CPU Registers used: A,B,H,L

```
Reserved locations used: None
Input/Output ports used: None
Subroutines called: None
Alternate entry points: None

6  140     056     TYMTAG,LHI  003      / Set memory byte pointer
           003                          / to page 3, byte 227.
6  142     066           LLI   227      / The QLOOK buffer pointer
           227                          / for page 076 buffer.
6  144     317           LBM            / Get pointer value in B.
6  145     010           INB            / Increment pointer.
6  146     371           LMB            / Restore buffer pointer.
6  147     361           LLB            / Set memory byte pointer.
6  150     056           LHI   076      / Set memory page to 076.
           076
6  152     307           LAM            / Get buffer pointer value
6  153     074           CPI   377      / Is value = ? character ?
           377
6  155     110           JFZ   006  140 / Jump to TYMTAG until
           140                          / first ? found in buffer.
           006
6  160     007           RET            / end of TYMTAG routine.


Subroutine RDRCNTL.
Description.  Turns paper tape reader ON, reads one byte, and
              then turns paper tape reader OFF with each call.
Entry point: 06-161
End of routine: 06-175
CPU Registers used: A,B
Reserved locations used: None
Input/Output ports used: OUT+22, COMMAND Latch Register
                         INP+0, INPUT from TTY
Subroutines called: RDY
Alternate entry points: None

6  161     006    RDRCNTL,LAI  001      / Load turn paper tape
           001                          / reader ON command.
6  163     123           OUT+22         / Output to COMMAND reg.
6  164     106           CAL   005  036 / Call RDY routine.
           036                          / (tests for reader ready
           005                          / status)
6  167     101           INP+0          / Input TTY tape BYTE.
6  170     310           LBA            / Store reg A in reg B.
6  171     006    RDROFF,LAI  000       / Load turn paper tape
           000                          / reader OFF command.
6  173     123           OUT+22         / Send command.
6  174     301           LAB            / Restore A value from B.
6  175     007           RET            / end of RDRCNTL routine.
6  176     000           HLT
6  177     000           HLT


Subroutine MIN.
Description.  Outputs eight programmable one-bit commands to
              the experiments.  Currently programmed for one
              minute commands to the Laser, Vislab, Eppley, and
              Barnes.  Call to DWTFMT is to allow a delay for
              Eppley filter step pulse.  Commands are given at
```

```
                the end of the one minute sampling scan of all
                channels.
Entry point: 06-200
End of routine: 06-243
CPU Registers used: A,E
Reserved locations used: None
Input/Output ports used:  OUT+34, EXPERIMENT Latch Register
Subroutines called: DWTFMT
Alternate entry points: None

6  200     304        MIN,LAE            / Get sample time mask, E.
6  201     044            NDI  010       / Mask with 00001000 to
           010                            / test bit 3 rate (1'/10')
6  203     110            JFZ  006  211  / Jump to MIN2 if bits
           211                            / match, otherwise
           006                            / continue.
6  206     104            JMP  006  217  / Jump to MIN1 link.
           217
           006
6  211     006       MIN2,LAI  017       / Load experiment command
           017                            / register with 00001111.
6  213     135            OUT+34         / Output to EXP. COMND.
6  214     104            JMP  006  233  / Jump to GO.
           233
           006
6  217     304       MIN1,LAE            / Get sample time mask, E.
6  220     044            NDI  002       / Mask with 00000010 to
           002                            / test for 1 min, cont.
6  222     110            JFZ  006  230  / Jump to MIN3 if on bit
           230                            / 1 sample rate.
           006
6  225     104            JMP  006  233  / Jump to GO
           233
           006
6  230     006       MIN3,LAI  013       / Load experiment register
           013                            / with 00001011.
6  232     135            OUT+34         / Output to EXP. COMND.
6  233     340         GO,LEA            / Save reg A in reg E.
6  234     106            CAL  004  140  / Call DWTFMT routine.
           140                            / (writes data word to
           004                            / tape)(40 microsec delay)
6  237     304            LAE            / Restore value to A.
6  240     044            NDI  004       / Mask with 00000100 to
           004                            / reset all but bit 2.
6  242     135            OUT+34         / Output to EXP. COMND.
6  243     007            RET            / end of MIN routine.
6  244     000            HLT


Subroutine BLKCTR.
Description.  Accumulates the total number of blocks written to
              the magnetic tape with the low byte stored in
              03-372 and the high byte stored in 03-373.
Entry point: 06-250
End of routine: 06-267
CPU Registers used: A,B,L
Reserved locations used: BLKCTR high byte at 03-373
                         BLKCTR low byte at 03-372
Input/Output ports used: None
```

```
Subroutines called: STCK
Alternate entry points: None

6  250     066     BLKCTR,LLI  373      / Set byte pointer to low
           373                          / BLK CTR address.
6  252     317           LBM            / Get stored value.
6  253     010           INB            / Increment it.
6  254     371           LMB            / Restore it in memory.
6  255     110           JFZ   006  264 / Jump to CONT if low
           264                          / BLK CTR byte not zero.
           006
6  260     061           DCL            / Point to high BLK CTR.
6  261     317           LBM            / Get stored value.
6  262     010           INB            / Increment it.
6  263     371           LMB            / Restore it in memory.
6  264     106           CAL   002  070 / Call STCK routine.
           070                          / (tests for tape recorder
           002                          / status)
6  267     007           RET            / end of BLKCTR routine.
6  270     000           HLT


Program INSTIN.
Description: Allows entry of machine coded instructions from the
             TTY keyboard.  Displays current contents on DATA
             Latch Register LED readout, if selected.
             Program asks for page as H=    , and for on page byte
             address as L=    .  Accepts three octal digits from
             the keyboard and packs them into the current byte
             pointer location.  Addresses are automatically
             incremented to the end of the current page.  P/O
             utility program package to allow on-site program
             updates and changes.
Entry point: 06-300
End of routine: 06-355
CPU Registers used: A,H,L
Reserved locations used: None
Input/Output ports used: OUT+20, OUTPUT to TTY
                         OUT+24, OUTPUT to DATA Latch Register
Subroutines called: CRLF, PRDY, SPACE, PROGIN
Alternate entry point: None

6  300     106     INSTIN,CAL  006  100 / Call CRLF routine.
           100
           006
6  303     106           CAL   005  136 / Call PRDY routine.
           136
           005
6  306     006           LAI   110      / Load ASCII character H.
           110
6  310     121           OUT+20         / Output it to TTY.
6  311     106           CAL   005  356 / Call SPACE routine.
           356                          / (types two spaces on
           005                          / current line)
6  314     106           CAL   005  200 / Call PROGIN routine.
           200                          / (packs 3 input digits
           005                          / into one octal byte)
6  317     350           LHA            / Load page value.
6  320     106           CAL   006  100 / Call CRLF routine.
```

```
                100
                006
6  323          106          CAL  005  136 / Call PRDY routine.
                136
                005
6  326          006          LAI  114      / Load ASCII character L.
                114
6  330          121          OUT+20        / Output it to TTY.
6  331          106          CAL  005  356 / Call SPACE routine.
                356
                005
6  334          106          CAL  005  200 / Call PROGIN routine.
                200
                005
6  337          360          LLA           / Set byte pointer.
6  340          106       TIE,CAL  006  100 / Call CRLF routine.
                100                        / (sets a carriage return
                006                        / and a line feed on TTY)
6  343          307          LAM           / Get current value stored
6  344          125          OUT+24        / Output to DATA Latch.
6  345          106          CAL  005  200 / Call PROGIN routine.
                200
                005
6  350          370          LMA           / Store input value.
6  351          060          INL           / Increment byte pointer.
6  352          104          JMP  006  340 / Jump to TIE and get next
                340                        / octal input value.
                006
6  355          000          HLT           / end of INSTIN routine.
6  356          000          HLT
6  357          000          HLT
```

Subroutine PUSH A.
Description: Stores current value of register A on page 06, byte 357 for later retrival.
Entry point: 06-360
End of routine: 06-365
CPU Registers used: A,H,L
Reserved locations used: STORE A at 06-357
Input/Output ports used: None
Subroutines called: None
Alternate entry point: None

```
6  360          056       PUSHA,LHI  006      / Set memory byte pointer
                006                           / to page 6, byte 357.
6  362          066          LLI  357
                357
6  364          370          LMA              / Store register A value.
6  365          007          RET              / end of PUSH A routine.
```

Subroutine POP A.
Description: Restores value stored on page 06, byte 357 to register A. Although the stack is only one level deep, it can be expanded to any depth by reassigning the stack array location.
Entry point: 06-366
End of routine: 06-374

```
CPU Registers used: A,H,L
Reserved locations used: Stack byte 06-357
Input/Output ports used: None
Subroutines called: None
Alternate entry point: None

6  366     056        POPA,LHI  006      / Set memory byte pointer
           006                             / to page 6, byte 357.
6  370     066             LLI  357
           357
6  372     307             LAM           / Load register A from M.
6  373     007             RET           / end of POP A routine.
6  374     000             HLT
6  375     000             HLT
6  376     000             HLT
6  377     000             HLT



Subroutine LOADER.
Description: Loads the buffer area, page 76, bytes 000 to 377
             in a circular fashion with TIME and DATA words as
             they are recorded on masnetic tape.  A dump of this
             buffer by the program GLOOK gives a dynamic picture
             of the data logger scanning and recording sequence.
Entry point: 07-000
End of routine: 07-031
CPU Registers used: A,B,H,L
Reserved locations used: GLOOK buffer array, page 76, bytes 000-37
Input/Output ports used: None
Subroutines called: None
Alternate entry points: None

7    0     016     LOADER,LBI  360      / Set byte pointer to 360.
           360                             / (1st byte of SHIFT)
7    2     056       LOOP,LHI  003      / Set memory page pointer
           003                             / to page 3.
7    4     010             INB           / Increment byte pointer.
7    5     301             LAB           / Load pointer to A.
7    6     074             CPI  367      / Test for byte 367?
           367                             / (at end of SHIFT array?)
7   10     150             JTZ  007  031 / Jump to OUT if at byte
           031                             / 367.
           007
7   13     361             LLB           / Load B value to L.
7   14     307             LAM           / Load Memory to A.
7   15     066             LLI  227      / Get BUFFER array byte
           227                             / pointer.
7   17     327             LCM           / Load to register C.
7   20     020             INC           / Increment C.
7   21     372             LMC           / Store BUFFER pointer.
7   22     362             LLC           / Set memory byte to C.
7   23     056             LHI  076      / Set memory page to 076.
           076
7   25     370             LMA           / Store A value in Memory.
7   26     104             JMP  007  002 / Jump to LOOP.
           002
           007
```

```
7   31      007         OUT,RET             / end of LOADER routine.
7   32      000             HLT


Subroutine LDLINK.
Description: Short "patch" routine used by the subroutine TWTFMT
             to load current TIME word into the GLOOK buffer.
Entry point: 07-050
End of routine: 07-56
CPU Registers used: None
Reserved locations used: None
Input/Output ports used: None
Subroutines called: PACKER, LOADER
Alternate entry point: None

7   50      106     LDLINK,CAL  002  320 / Call PACKER routine.
            320                         / (packs ASCII time word
            002                         / into hex bytes in SHIFT)
7   53      106             CAL  007  000 / Call LOADER routine.
            000                         / (loads GLOOK buffer with
            007                         / time/data words )
7   56      007             RET         / end of LDLINK routine.
7   57      000             HLT


Subroutine AEGSEC. (Formerly LUXSEC)
Description: Controls the setting and resetting of the n-second
             sampling bit (#5) in the TIME mask in register E to
             control the AEG sampling rate according to the table:
             Loc 07-111        Loc 07-173      Sample Interval
                   004               003           5 sec
                   011               010          10 sec
                   016               015          15 sec
                   023               022          20 sec
                   030               027          25 sec
                   034               035          30 sec
Entry point: 07-100
End of routine: 07-124
CPU Registers used: A,B,E,L
Reserved locations used: TYMSYNC counter at 03-377
Input/Output ports used: None
Subroutines called: None
Alternate entry points: None
Note.  Set LOC 100 as: 007 = AEGSEC OFF
                       066 = AEGSEC ON

7  100      066     AEGSEC,LLI  377      / Set memory byte pointer
            377                         / to 377, TYMSYN counter.
7  102      307             LAM          / Get TYMSYN counter in A.
7  103      074             CPI  000     / Is value stored 0 ?
            000
7  105      110             JFZ  007  121 / Jump to CTR  if counter
            121                         / is NOT zero.
            007
7  110      076             LMI  023     / Set TYMSYN = 023.
            023                         / Set 20 second interval
7  112      304             LAE          / Get sample time mask in E.
7  113      064             ORI  040     / Mask with 00100000 to sec n-
            040                         / second sample rate.
```

```
7  115     340            LEA             / Store sample time mask in E.
7  116     104            JMP   007  124  / Jump to EXIT.
           124
           007
7  121     317       CTR,LBM              / Move TYMSYN byte to B.
7  122     011            DCB             / Decrement B.
7  123     371            LMB             / Store TYMSYN byte.
7  124     007      EXIT,RET              / end of AEGSEC routine.
7  125     000            HLT
7  126     000            HLT
7  127     000            HLT
7  130     000            HLT
7  131     000            HLT
7  132     000            HLT
7  133     000            HLT
7  134     000            HLT
7  135     000            HLT
7  136     000            HLT
7  137     000            HLT
7  140     076            LMI   060      / Not used.
           060                           /
7  142     104            JMP   007  147  / Not used.
           147
           007
7  145     076            LMI   062      / Not used.
           062
7  147     007            RET            / Not used.
```

Subroutine AEGLOC. (Formerly LUXLOC)
Description: Tests 10's of seconds and unit seconds for the value 0 (decimal). The test is on the TIME array locations 03-211 and 03-212 which contain ASCII digits. If both 10's and unit seconds are zero, resets TYMSYNC counter at 03-377 to zero. Synchronizes on minute time changes.
Entry point: 07-150
End of routine: 07-177
CPU Registers used: A,L
Reserved locations used: TIME array locations 03-211 and 03-212
TYMSYNC counter at 03-377
Input/Output ports used: None
Subroutines called: AEGSEC
Alternate entry points: None

```
7  150     066    AEGLOC,LLI   211      / Get 10's seconds byte.
           211
7  152     307            LAM            / Move to A.
7  153     074            CPI   060      / Compare with ASCII code
           060                           / for digit 0.
7  155     110            JFZ   007  201  / Jump to SKIP if not at
           201                           / 10's seconds =0.
           007
7  160     066            LLI   212      / Get unit seconds digit.
           212
7  162     307            LAM            / Move to A.
7  163     074            CPI   060      / Compare with ASCII code
           060                           / for 0.
7  165     110            JFZ   007  201  / Jump to SKIP if unit
```

```
                201                                 / seconds not zero.
                007
7   170         066             LLI  377            / Set memory byte pointer
                377                                 / for TYMSYN counter.
7   172         076             LMI  022            / Set TYMSYN counter= 022.
                022                                 / Set for 20 second interval.
7   174         304             LAE                 / Get sample time mask in E.
7   175         064             ORI 040             / Mask with 00100000 to set n-
                040                                 / second sampling enable.
7   177         340             LEA                 / Store sample time mask in E.
7   200         007             RET
7   201         106         SKIP,CAL 007 100        / Call AEGSEC.
7   202         100
7   203         007
7   204         007             RET                 / End of AEGLOC.
7   205         000             HLT
7   206         000             HLT
7   207         000             HLT
```

Program GLOOK.
Description. Prints out the last 256 bytes written to the magnetic tape and returns control to the MAIN program. Formats the printout with one time word or data word on each line of printout.
Entry point: 07-210
End of routine: 07-232
CPU Registers used: E
Reserved locations used: GLOOK array, all of page 76
Input/Output ports used: None
Subroutines called: TYMTAG, XFER, DPTFMT
Alternate entry points: None

```
7   210         106         GLOOK,CAL  006  140 / Call TYMTAG routine.
                140                             / (locates 1st ? character
                006                             / in GLOOK buffer)
7   213         046             LEI  052        / Set # print lines
                052                             / counter.
7   215         106           RUN,CAL  007  242 / Call XFER routine.
                242                             / (transfers buffer bytes
                007                             / to SHIFT for printing)
7   220         106             CAL  003  000 / Call DPTFMT routine.
                000                             / (formats bytes in SHIFT
                003                             / array, HEX to ASCII)
7   223         041             DCE             / Decrement E.
7   224         110             JFZ  007  215 / Jump to RUN until E
                215                             / lines are printed.
                007
7   227         104             JMP  000  073 / Jump to MAIN, re-enter
                073                             / the auto sample/write
                000                             / to mag tape mode.
7   232         000             HLT             / end of GLOOK routine.
```

Subroutine XFER.
Description: Transfers bytes stored in GLOOK array (page 76) to SHIFT array for printing.
Entry point: 07-242
End of routine: 07-274

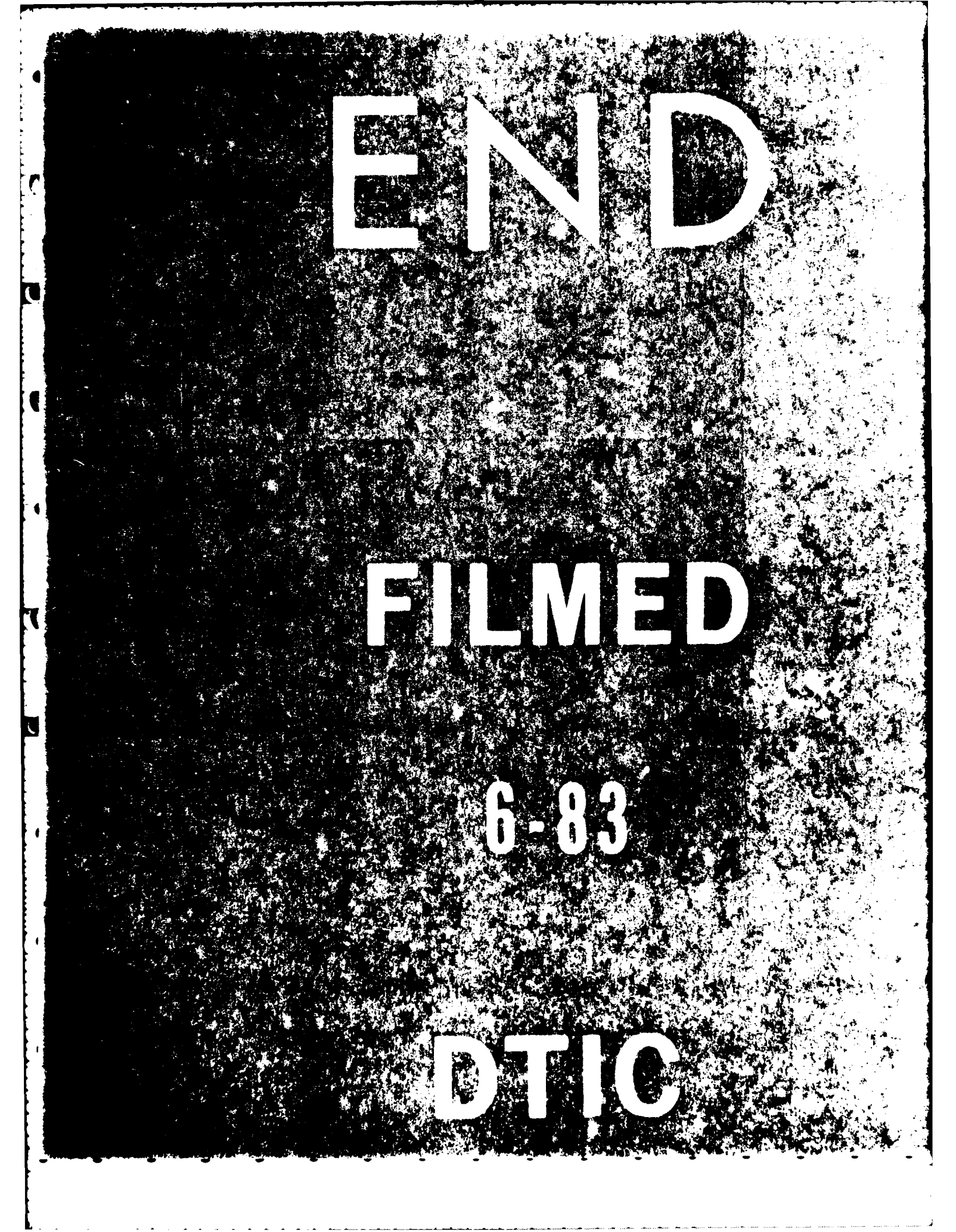
```
CPU Registers used: A,B,C,H,L
Reserved locations used: QLOOK array, all of page 76
                         SHIFT array locations 03-361 to 03-366
Input/Output ports used: None
Subroutines called: None
Alternate entry points: None

7  242     026        XFER,LCI  361       / Set SHIFT array pointer
           361                             / to byte 1.
7  244     056         AGN,LHI  003       / Set memory byte pointer
           003                             / to page 3, byte 227.
7  246     066             LLI  227       / QLOOK buffer pointer.
           227
7  250     317             LBM            / Store pointer in B.
7  251     367             LLM            / Set memory byte = B.
7  252     056             LHI  076       / Set memory page pointer
           076                             / to page 076.
7  254     307             LAM            / Get buffer byte in A.
7  255     056             LHI  003       / Set memory page pointer
           003                             / to page 3.
7  257     362             LLC            / Set SHIFT byte pointer.
7  260     370             LMA            / Buffer byte to SHIFT.
7  261     010             INB            / Increment buffer pointer
7  262     066             LLI  227       / Set memory byte pointer
           227                             / to 227.
7  264     371             LMB            / Store buffer pointer.
7  265     020             INC            / Increment line counter.
7  266     302             LAC            / Move C to A.
7  267     074             CPI  367       / Is pointer value = 367?
           367
7  271     110             JFZ  007  244  / Jump to AGN until
           244                             / a complete time or data
           007                             / word transfered to SHIFT
7  274     007             RET            / end of XFER routine.
7  275     000             HLT
7  276     000             HLT
7  277     000             HLT


Subroutine ADTEST.
Description. A test program that continuously samples the analog
             channel selected by the CONSOLE switches (octal).
             The analog channel number is displayed on the
             ANALOG ADDRESS Latch Register and the channel
             discrete bits are displayed on the DATA Latch
             Register LEDs.
Entry point: 07-300
End of routine: 07-341
CPU Registers used: A,H,L
Reserved locations used: None
Input/Output ports used: INP+6, CONSOLE Switches
                         OUT+24, DATA Latch Register
Subroutines called: CLEAR, DPTFMT, DIGMUX, LINK in CHTEST
Alternate entry points: None

7  300     106      ADTEST,CAL  004  200 / Call CLEAR routine.
           200                             / (initializes counters
           004                             / and pointers)
7  303     056             LHI  002       / Set memory byte pointer
```

```
                002                              / to page 2, byte 200.
7  305          066             LLI  200         / Defeats call for MRCDR
                200                              / to write to mag tape.
7  307          076             LMI  007         / Replace code with RET.
                007
7  311          107        AGIN,INP+6            / Input CONSOLE switches.
7  312          064             ORI  300         / OR with 11000000  to set
                300                              / REQUEST array address.
7  314          056             LHI  003         / Set memory page pointer
                003                              / to page 3.
7  316          360             LLA              / Set memory byte = A.
7  317          106             CAL  000  270    / Call LINK entry in
                270                              / CHTEST routine.
                000
7  322          106             CAL  003  000    / Call DPTFMT routine.
                000                              / (converts and prints
                003                              / hex data word)
7  325          106             CAL  004  000    / Call DIGMUX routine.
                000                              / (loads SHIFT with data
                004                              / word bytes)
7  330          056             LHI  003         / Set memory byte pointer
                003                              / to page 3, byte 364.
7  332          066             LLI  364         / Pointers to discrete
                364                              / data byte in SHIFT.
7  334          307             LAM              / Load to A.
7  335          125             OUT+24           / Output to DATA latch.
7  336          104             JMP  007  311    / Jump to AGN.
                311
                007
7  341          000             HLT              / end of ADTEST routine.
```

Subroutine ENDE.
Description: When called, terminates writing to the magnetic tape at the end of the current block. Writes one block of zero length and stops data logger.
Entry point: 07-342
End of routine: 07-373
CPU Registers used: H,L
Reserved locations used: None
Input/Output ports used: None
Subroutines called: MDUMP, STCK, GAP
Alternate entry ponts: None

```
7  342          056        ENDE,LHI  005         / Set memory byte pointer
                005                              / to page 5, byte 355.
7  344          066             LLI  355         / Replace instruction
                355                              / with RET.
7  346          076             LMI  007         / Do it.
                007
7  350          056             LHI  003         / Set memory byte pointer
                003                              / to page 3, byte 372.
7  352          066             LLI  372
                372
7  354          106             CAL  005  300    / Call MDUMP routine.
                300                              / (used for time delay)
                005
7  357          106             CAL  002  070    / Call STCK routine.
                070                              / (tests recorder status)
```

```
                002
7  362          106             CAL  002  171 / Call GAP routine.
                171                          / ( issues recorder GAP
                002                          / command)
7  365          056             LHI  005     / Set memory byte pointer
                005                          / to page 5, byte 355.
7  367          066             LLI  355     / Restores instruction
                355                          / in MDUMP to HLT(=000).
7  371          076             LMI  000     / Do it.
                000
7  373          000             HLT          / end of ENDE routine.
7  374          000             HLT
7  375          000             HLT
7  376          000             HLT
7  377          000             HLT
```


END
FILMED
6-83
DTIC